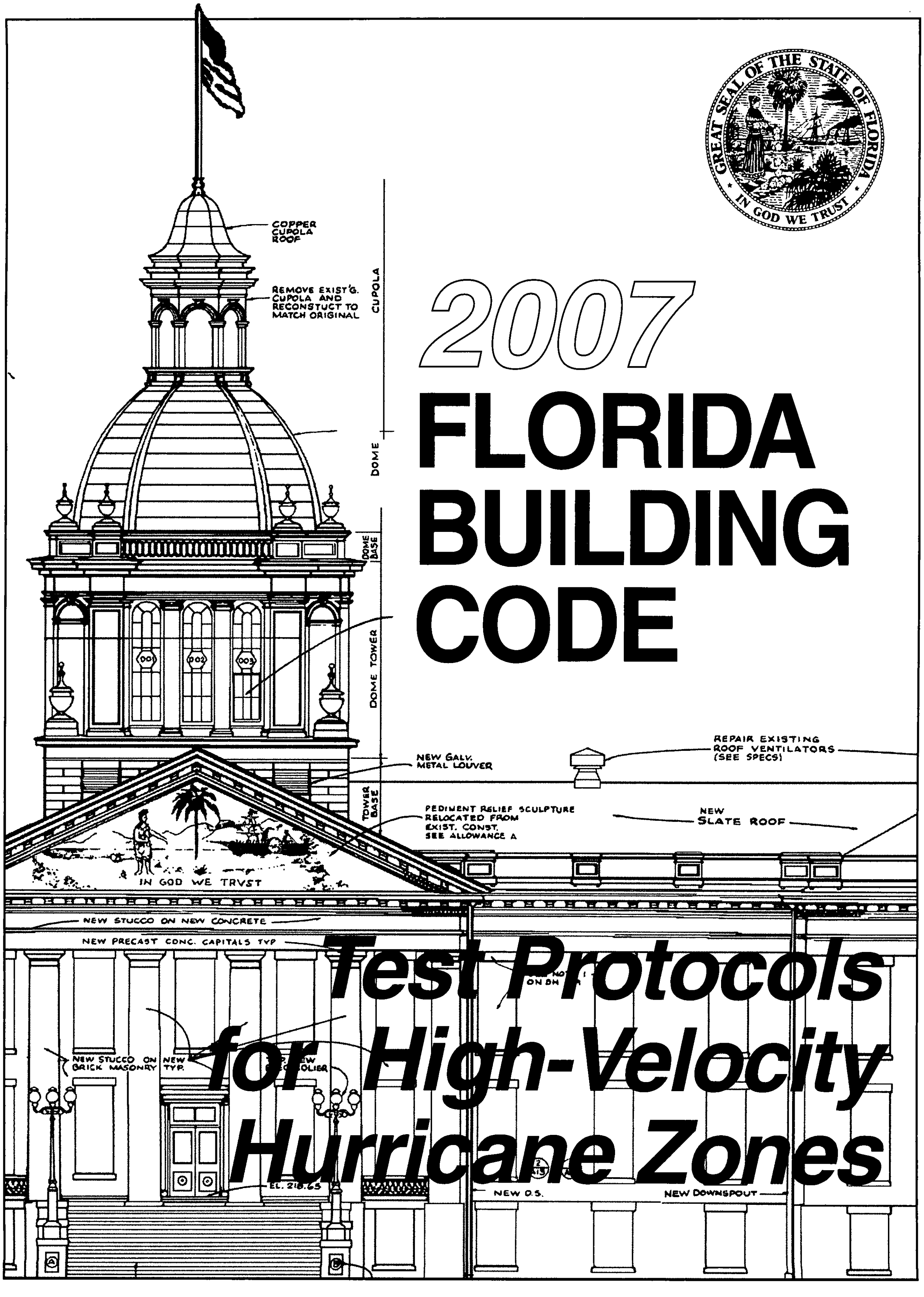
COPPER CUPOLA ROOF
REMOVE EXIST'G. CUPOLA AND RECONSTUCT TO MATCH ORIGINAL
CUPOLA
DOME
DOME BASE
DOME TOWER
TOWER BASE
NEW GALV. METAL LOUVER
REPAIR EXISTING ROOF VENTILATORS (SEE SPECS)
PEDIMENT RELIEF SCULPTURE RELOCATED FROM EXIST. CONST. SEE ALLOWANCE A
NEW SLATE ROOF
IN GOD WE TRVST
NEW STUCCO ON NEW CONCRETE
NEW PRECAST CONC. CAPITALS TYP
NEW STUCCO ON BRICK MASONRY
NEW TYP.
EL. 218.65
NEW D.S.
NEW DOWNSPOUT

GREAT SEAL OF THE STATE OF FLORIDA

2007
FLORIDA BUILDING CODE

Test Protocols for High-Velocity Hurricane Zones

2007 Florida Test Protocols for High Velocity Hurricane Zones

First Printing

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PREFACE

History

The State of Florida first mandated statewide building codes during the 1970s at the beginning of the modern construction boom. The first law required all municipalities and counties to adopt and enforce one of the four state-recognized model codes known as the "state minimum building codes." During the early 1990s a series of natural disasters, together with the increasing complexity of building construction regulation in vastly changed markets, led to a comprehensive review of the state building code system. The study revealed that building code adoption and enforcement was inconsistent throughout the state and those local codes thought to be the strongest proved inadequate when tested by major hurricane events. The consequences of the building codes system failure were devastation to lives and economies and a statewide property insurance crisis. The response was a reform of the state building construction regulatory system that placed emphasis on uniformity and accountability.

The 1998 Florida Legislature amended Chapter 553, Florida Statutes, Building Construction Standards, to create a single state building code that is enforced by local governments. As of March 1, 2002, the *Florida Building Code*, which is developed and maintained by the Florida Building Commission, supersedes all local building codes. The Florida Building Code is updated every three years and may be amended annually to incorporate interpretations and clarifications.

Scope

The *Florida Building Code* is based on national model building codes and national consensus standards which are amended where necessary for Florida's specific needs. The code incorporates all building construction-related regulations for public and private buildings in the State of Florida other than those specifically exempted by Section 553.73, Florida Statutes. It has been harmonized with the *Florida Fire Prevention Code*, which is developed and maintained by the Department of Financial Services, Office of the State Fire Marshal, to establish unified and consistent standards.

The base codes for the 2007 edition of the *Florida Building Code* include: the *International Building Code*®, 2006 edition; the *International Plumbing Code*®, 2006 edition; the *International Mechanical Code*®, 2006 edition; the *International Fuel Gas Code*®, 2006 edition; the *International Residential Code*®, 2006 edition; the *International Existing Building Code*®, 2006 edition; the *National Electrical Code*, 2005 edition; the U. S. Department of Housing and Urban Development, *Fair Housing Guidelines*, and; substantive criteria from the American Society of Heating, Refrigerating and Air-conditioning Engineers' (ASHRAE) Standard 90.1-2004. State and local codes adopted and incorporated into the code include the *Florida Energy Efficiency Code for Building Construction*, the *Florida Accessibility Code for Building Construction* and special hurricane protection standards for the high-velocity hurricane zone.

The code is composed of seven main volumes: the *Florida Building Code, Building,* which also includes Chapter 13 (energy efficiency) and Chapter 11(accessibility) as well as state regulations for licensed facilities; the *Florida Building Code, Plumbing*; the *Florida Building Code, Mechanical*; the *Florida Building Code, Fuel Gas*; the *Florida Existing Building Code*; the *Florida Building Code, Residential ;* and the *Florida Building Code, Test Protocols for High-Velocity Hurricane Zones.* Chapter 27 of the *Florida Building Code, Building,* adopts the *National Electrical Code*, NFPA 70, by reference. Chapter 33 of the *Florida Building Code, Residential* adopts the *National Electrical Code Requirements for One- and Two-Family Dwellings*, NFPA 70A, by reference.

Under certain strictly defined conditions, local governments may amend requirements to be more stringent than the code. All local amendments to the *Florida Building Code* must be adopted by local ordinance and reported to the Florida Building Commission then posted on www.floridabuilding.org in Legislative format for a month before being enforced. Local amendments to the *Florida Building Code* and the *Florida Fire Prevention Code* may be obtained from the Florida Building Commission web site, or from the Florida Department of Community Affairs or the Florida Department of Financial Services, Office of the State Fire Marshal, respectively.

Adoption and Maintenance

The *Florida Building Code* is adopted and updated with new editions triennially by the Florida Building Commission. It is amended annually to incorporate interpretations, clarifications and to update standards. Minimum requirements for permitting, plans review and inspections are established by the code, and local jurisdictions may adopt additional administrative requirements that are more stringent. Local technical amendments are subject to strict criteria established by Section 553.73, F.S. They are subject to commission review and adoption into the code or repeal when the code is updated triennially and are subject to appeal to the Commission according to the procedures established by Section 553.73, F.S.

Ten Technical Advisory Committees (TACs), which are constituted consistent with American National Standards Institute (ANSI) Guidelines, review proposed code changes and clarifications of the code and make recommendations to the Commission. These TACs whose membership is constituted consistent with American National Standards Institute (ANSI) Guidelines include: Accessibility; Joint Building Fire (a joint committee of the Commission and the State Fire Marshal); Building Structural; Code Administration/ Enforcement; Electrical; Energy; Mechanical; Plumbing and Fuel Gas; Roofing; and Special Occupancy (state agency construction and facility licensing regulations).

The Commission may only issue official code clarifications using procedures of Chapter 120, Florida Statutes. To obtain such a clarification, a request for a Declaratory Statement (DEC) must be made to the Florida Building Commission in a manner that establishes a clear set of facts and circumstances and identifies the section of the code in question. Requests are analyzed by staff, reviewed by the appropriate Technical Advisory Committee, and sent to the Florida Building Commission for a first action. Draft Declaratory Statements are subject to public comment and are finalized by the Commission at its next meeting. These interpretations establish precedents for situations having similar facts and circumstances and are typically incorporated into the code in the next code amendment cycle. Non-binding opinions are available from the Building Officials Association of Florida's web site (www.BOAF.net) and a Binding Opinion process is available online at www.floridabuilding.org.

Marginal Markings

Vertical lines in the margins within the body of the code indicate a change from the requirements of the base codes to the 2007 *Florida Building Code* effective October 1, 2008.

Sections deleted from the base code are designated "Reserved."

Acknowledgments

The *Florida Building Code* is produced through the efforts and contributions of building designers, contractors, product manufacturers, regulators and other interested parties who participate in the Florida Building Commission's consensus processes, Commission staff and the participants in the national model code development processes.

TABLE OF CONTENTS

RAS No. 109 ·················· (RAS) 109.1

RAS No. 109-A ················ (RAS)109-A.1

RAS No. 111 Standard Requirements for Attachment of Perimeter Wood Blocking and Metal Flashing ················ (RAS)111.1

RAS No. 113 Standard Requirements for Job Site Mixing of Roof Tile Mortar··· (RAS)113.1

RAS No. 115 Standard Procedures for Asphaltic Shingle Installation ········· (RAS)115.1

RAS No. 117 Standard Requirements for Bonding or Mechanical Attachment of Insulation Panels and Mechanical Attachment of Anchor and/or Base Sheets to Substrates ·········· (RAS)117.1

RAS No. 118 Installation of Mechanically Fastened Roof Tile Systems - System Two: Direct Deck & Counter Battens Only ·············· (RAS)118.1

RAS No. 119 Installation of Mechanically Fastened Roof Tile Systems - System One: Direct Deck & Horizontal Battens Only ·············· (RAS)119.1

RAS No. 120 Mortar and Adhesive Set Tile Application ········· (RAS)120.1

RAS No. 127 Procedure For Determining the Moment of Resistance and Minimum Characteristic Resistance Load to Install a Tile System on a Building of a Specified Roof Slope and Height ············· (RAS)127.1

RAS No. 128 Standard Procedures for Determining Applicable Wind Design Pressures for Low Slope Roofs ········ (RAS)128.1

RAS No. 130 Installation Criteria for Woof Shingles and Shakes Application ··· (RAS)130.1

RAS No. 133 Standard Procedures for Installation of Metal Roof Systems ·· (RAS)133.1

RAS No. 137 Standard Requirements for Mechanical Attachment of Single-Ply Roof Coverage of Various Substrates···· (RAS)137.1

RAS No. 150 Prescriptive BUR Requirements ················· (RAS)150.1

TAS 100 Test Procedure for Wind and Wind Driven Rain Resistance of Discontinuous Roof Systems ············ (TAS)100-95.1

TAS 100(A) Test Procedure for Wind and Wind Driven Rain Resistance and/or Increased Windspeed Resistance of Soffit Ventilation Strip and Continuous or Intermittent Ventilation System Installed at the Ridge Area ········· (TAS)100(A)-95.1

TAS 101 Test Procedure for Static Uplift Resistance of Mortar or Adhesive Set Tile Systems ········· (TAS)101-95.1

TAS 102 Test Procedure for Static Uplift Resistance of Mechanically Attached, Rigid Roof Systems ············ (TAS)102-95.1

TAS 102(A) Test Procedure for Static Uplift Resistance of Mechanically Attached, Clipped, Rigid Roof Systems ·· (TAS)102(A)-95.1

TAS 103 Test Procedure for Self-Adhered Underlayments for Use in Discontinuous Roof Systems ····· (TAS)103-95.1

TAS 104 Test Procedure for Nail-On Underlayments for Use in Discontinuous Roof Systems ········· (TAS)104-95.1

TAS 105 Test Procedure for Field Withdrawal Resistance Testing · (TAS)105-98.1

TAS 106 Standard Procedure for Field Verification of the Bonding of Mortar or Adhesive Set Tile Systems and Mechanically Attached, Rigid, Discontinuous Roof Systems ············ (TAS)106.1

TAS 107 Test Procedure for Wind Resistance Testing of Non-Rigid, Discontinuous Roof System Assemblies······· (TAS)107-95.1

TAS 108 Test Procedure for Wind Tunnel Testing of Air Permeable, Rigid, Discontinuous Roof Systems ········· (TAS)108-95.1

TAS 110	Testing Requirements for Physical Properties of Roof Membranes, Insulation, Coatings and Other Roofing Components	(TAS)110-00.1
TAS 111(A)	Test Procedure for Roof Edge Termination Performance	(TAS)111(A)-95.1
TAS 111(B)	Test Procedure for Edge Metal Pull-Off Performance	(TAS)111(B)-95.1
TAS 111(C)	Test Procedure for Coping Cap Pull-Off Performance	(TAS)111(C)-95.1
TAS 112	Standard Requirements for Concrete Roof Tiles	(TAS)112-95.1
TAS 114	Test Procedures for Roof System Assemblies in the High-Velocity Hurricane Zone Jurisdiction	(TAS)114-95.1
TAS 116	Test Procedure for Air Permeability Testing of Rigid, Discontinuous Roof Systems	(TAS)116-95.1
TAS 117(A)	Test Procedure for Withdrawal Resistance Testing of Mechanical Fasteners Used in Roof System Assemblies	(TAS)117 (A)-95.1
TAS 117(B)	Test Procedure for Dynamic Pull-Through Performance of Roofing Membranes over Fastener Heads or Fasteners with Metal Bearing Plates	(TAS)117(B)-95.1
TAS 117(C)	Test Procedure for Dynamic Pull-Off Performance of Roofing Fastener Heads or Fasteners with Bearing Plates	(TAS)117(C)-95.1
TAS 121	Standard Requirements for Testing and Approval of Roofing Adhesives, Mastics and Coatings	(TAS)121-95.1
TAS 123	Standard Requirements for Mortar Used in Mortar Set Tile Systems	(TAS)123-95.1
TAS 124	Test Procedure for Field Uplift Resistance of Existing Membrane Roof Systems and In Situ Testing for Reroof and New Construction Applications	(TAS)124-95.1
TAS 125	Standard Requirements for Metal Roofing Systems	(TAS)125-03.1
TAS 126	Standard Procedures for Roof Moisture Surveys	(TAS)126-95.1
TAS 131	Standard Requirements for Thermoplastic Olefin Elastomer Based Sheet Used in Single-Ply Roof Membrane	(TAS)131-95.1
TAS 132	Standard Requirements for Testing and Approval of Sealants Used in Roofing	(TAS)132-95.1
TAS 135	Standard Requirements for Fiberglass Reinforced Tile, Shingles or Panels and Fiber Cement Shingles, Shakes or Panels	(TAS)135-95.1
TAS 138	Standard Requirements for Aluminum Pigmented Emulsified Asphalt Used as a Protective Coating for Roofing	(TAS)138-95.1
TAS 139	Standard Requirements for White Roof Patch Specification	(TAS)139-95.1
TAS 140	Standard Requirements for Nonfibered Roof and Foundation Coatings	(TAS)140-95.1
TAS 141	Standard Requirements for Coal Tar (Cutback) Roof Coating, Brushing Consistency	(TAS)141-95.1
TAS 142	Standard Requirements for Coal Tar Roof Cement, Asbestos Free	(TAS)142-95.1
TAS 143	Standard Requirements for White Elastomeric Roof Coatings Used for Coating Built Up Roofs and Metal Roofing Systems	(TAS)143-95.1
TAS 201	Impact Test Procedures	(TAS)201-94.1
TAS 202	Criteria for Testing Impact and Non-Impact Resistant Building Envelope Components Using Uniform Static Air Pressure	(TAS)202-94.1
TAS 203	Criteria for Testing Products Subject to Cyclic Wind Pressure Loading	(TAS)203-94.1
TAS 301	Testing Laboratory	(TAS)301-94.1

ROOFING APPLICATION STANDARD (RAS) No. 109

1. Scope

1.1 This Roofing Application Standard sets the requirements to determine whether a substrate and surrounding environmental conditions are appropriate for the application of a spray applied polyurethane foam Roof Assembly; whether the final application is in compliance with the requirements of the *Florida Building Code, Building* and, whether proposed details are in compliance with industry standards.

2. Referenced Documents

2.1 For definitions of terms used in this application standard, refer to ASTM D 1079; and the *Florida Building Code, Building*.

3. Significance and Use

3.1 The test procedures outlined herein provide a means for establishing the use of industry accepted details of spray applied polyurethane foam Roof Assemblies, proper substrate and environmental conditions at the time of application, and methods of quality control during and after application of the Roof Assembly.

3.2 Quality control test methods are intended to confirm compliance with the wind load requirements of Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* and compliance with the spray applied polyurethane foam Roof Assembly manufacturer's Product Approval.

4. General Requirements

4.1 All spray applied polyurethane foam (PUF) Roof Assemblies shall have Product Approval. Spray applied polyurethane manufacturers' Product Approval shall include all components used in accepted systems, and manufacturers environmental constraints concerning application temperatures and relative humidity.

4.2 All spray applied polyurethane foam (PUF), and coatings applied over spray applied polyurethane foam shall comply with Section 1521 of the *Florida Building Code, Building*.

4.3 All spray applied polyurethane foam applications shall have a minimum slope of $^1/_4$ in.:12 in. The application shall be applied to eliminate ponding. Ponding, for the purposes of this Roofing Application Standard, shall be defined as an area of 100 ft^2 or more which holds $^1/_2$ in. or more of water as measured 24 hours after a rain fall.

4.4 Certification of a completed spray applied polyurethane foam Roof System Assembly shall be provided to the building official within 30 days of job completion as detailed in Section 1521 of the *Florida Building Code, Building*.

4.5 The minimum finished thickness of all spray applied polyurethane foam applications shall be not less than 1 in. A foam pass (or lift) shall not be less than 0.50 in. in thickness.

4.6 The spray polyurethane foam shall be uniformly terminated a minimum of four inches above the roof line at all penetrations (except drains, parapet walls or building junctions). Foamed in place cants shall be smooth and uniform to allow for positive drainage.

4.7 The spray polyurethane foam shall be terminated below existing weep holes at through wall flashings. Weep holes shall not be covered with foam or coatings.

5. Details

5.1 Model details for spray applied polyurethane foam applications are provided in Appendix 'A,' herein.

6. General Practices – The following general practices shall be observed prior to and during the application of spray applied polyurethane foam:

6.1 A Job Log shall be maintained on the job site in a ring binder, including but not limited to:

- Roof Assembly Product Approval
- Section II of the Uniform Building Permit Application
- All pre-job testing
- All job testing detailed in this Roofing Application Standard
- Daily weather conditions
- All written or verbal communications with spray applied polyurethane foam

roof assembly manufacturer relating to the application
- A list of all accessory products used within the Roof Assembly; and,
- All material safety data sheets

6.2 The building official shall have access to the Job Log during site inspections.

6.3 The roof deck shall be securely fastened to the building structure in compliance with the requirements set forth in the relevant decking chapter of the *Florida Building Code, Building.*

6.4 Surface preparation of the roof decking shall be in compliance with the Guide Specifications of the Polyurethane Foam Contractors Division, Section 3.02.

6.5 For spray applied polyurethane foam applications over an existing built-up Roof Assembly, the existing Assembly shall be tested for uplift resistance in compliance with TAS 124 to confirm compliance with design pressures determined in compliance with Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

6.6 Should the existing roof assembly fail to meet the required design pressures, additional mechanical attachment consisting of approved insulation fasteners and stress plate assemblies at a density calculated in compliance with RAS 117 and Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* may be provided. Alternatively the existing roof assembly, including any insulation substrate, may be removed to the structural deck.

7. Adhesion to Substrate

7.1 Spray-applied polyurethane foam may be applied to a large variety of substrate materials including but not limited to concrete, painted steel, galvanized steel, gravel-surfaced built-up roofing, smooth surface built-up roofing, synthetic membranes, and coatings. If an adhesion of the spray applied polyurethane foam to the specific existing substrate is not listed in the manufacturer's Product Approval, adhesion testing may be conducted in compliance with TAS 124.

7.1.1 A minimum of three adhesion tests shall be conducted in each roof area (i.e. field, perimeter and corner areas). The test report shall include results from each adhesion test as well as a mean value of the sample.

7.1.2 Average adhesion test results in each respective roof area shall meet or exceed 1.45 times the design pressure for that respective roof area, calculated in compliance with Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

7.1.3 If primer is used in the test specimen construction, then primer shall be required as a part of the application. The spray applied polyurethane foam manufacturer shall provide primer application instructions together with material safety data sheets and acceptable environmental conditions for application.

7.1.4 The adhesion test report shall be attached to Section II of the Uniform Building Permit Application, and submitted to the building official for review.

7.2 Prior to application of any spray applied polyurethane foam, the substrate surface shall be clean; dry; free from loose dirt or any contaminants that may interfere with proper adhesion of any of the Roof Assembly components. Any deteriorated sections of deck or membrane shall be removed and replaced in compliance with this code.

7.2.1 Deck contaminants and debris shall be removed by methods approved by the spray applied polyurethane foam manufacturer. The application substrate shall be in similar condition to the substrate tested for adhesion performance.

7.3 Areas to receive spray-applied polyurethane foam shall be thoroughly examined and tested for moisture immediately prior to foam application, particularly early in the morning and late in the afternoon, when condensation is most likely to be present. Testing shall be carried out on all areas, including those areas that appear dry to sight and touch.

7.3.1 Moisture detection shall be conducted using moisture detection paper or other moisture detection device that is sensitive to small quantities of surface moisture.

7.3.2 Results of all moisture testing shall be recorded in the job log including: 1) the type of testing; 2) the area(s) tested; 3) the time; and 4) the results.

7.3.3 A minimum of six moisture tests shall be conducted. All test results shall be recorded in the Job Log.

7.3.4 Moisture test shall be conducted: 1) not less than three more for every additional 100 squares of roof area; 2) not less than every twelve feet in the direction of the deck slope; and 3) within five feet of each drain.

7.3.5 The building official may, at his/her discretion, request additional moisture tests in areas to be foamed and/or may require examination of foam already in place to examine cell structure.

7.3.6 Where testing is carried out at areas already foamed, a minimum of 3 to 4 inches in diameter core sample of foam shall be removed to the substrate level. Where the foam has been applied to a monolithic substrate, the sample shall be scraped from the substrate, bagging all pieces of the sample and labeling the bag with: 1) the date of application; 2) the date of sampling; 3) the person taking the sample; and 4) a general description of material bagged.

7.3.6.1 Samples shall be forwarded to an approved testing agency for cell analysis. If inferior or irregular cell structure is observed, a "Bonded Pull Test," in compliance with TAS 124, shall be carried out in areas of inferior or irregular cell structure or as directed by the building official.

7.3.6.2 Results of all testing shall be submitted to building official for review.

8. Moisture at Application Nozzles

8.1 Functional air dryers shall be installed on all air inlets to spray equipment to eliminate moisture contamination. The building official may, at his/her discretion, test the spray gun assembly for moisture using moisture detection paper or some other type of moisture detection to verify dry purge air.

8.2 The roofing contractor shall test nozzles not less than twice each day and record the results in the Job Log.

9. Humidity

9.1 Water vapor in humid air can react with a curing foam surface resulting in a weakened bond with the ensuing layer of foam. Humidity can create a weakness in the bond lines of multiple foam passes.

9.2 Care shall be taken to monitor humidity conditions during applications. Application shall cease when humidity levels are above the acceptable levels described in the foam manufacturer's Product Approval.

9.3 The building official may direct testing of areas installed during high humidity conditions.

9.4 All spray-applied polyurethane foam Roof Assemblies Product Approval shall include a chart of ambient temperature and humidity application limits. Ambient humidity shall be monitored in all projects with a sling or self-contained psychrometer. Readings shall be taken before spray applications commence and every two hours while spraying. All readings shall be recorded in the Job Log.

10. Visual Inspections

10.1 Slit test samples of a minimum $^1/_2$ in. wide, 2 in. to 3 in. long and least $^3/_4$ in. deep shall be cut at a minimum of one sample every 2,500 ft^2 for visual observation and testing. In addition, one slit sample within ten feet of each drain shall be taken.

10.2 Samples shall be marked and bagged in an air tight polyurethane bags and stored until project completion. Bags shall be identified with date and location of core sampling.

10.3 A list of all stored samples shall be maintained in the Job Log. The building official may request laboratory testing of samples during the period of construction or prior to final inspection.

10.4 Applied foam shall be visually examined for cell structure and uniformity of color. Bond lines shall also be examined for adhesion. Results of the visual examination shall be recorded in the Job Log.

11. Laboratory Examination

11.1 Round core samples having a diameter not less than 3 inches shall be taken at a minimum of one sample every 10,000 ft^2 at the thickest application of foam.

11.2 Samples shall be taken by approved testing agency, and shall provide a written report of the visual examination of color, cell structure and adhesion at bond lines. Copies of the reports shall be kept in the Job Log for reference by the building official.

11.3 Final inspection shall not be complete without satisfactory test reports on file at job completion.

12. Remedial Repairs

12.1 Should irregularities be found during visual or laboratory examination of slit or core samples, the surrounding area shall be examined by removing additional slit or core samples working outward from the initial sample location until the foam is determined to be satisfactory by an approved testing agency. All inferior foam shall be removed and replaced.

12.2 If areas requiring remedial repair have been determined to be inferior by the designated testing agency, core samples on all sides of the repair area shall be taken and forwarded to the approved testing agency for examination. If the repair area is coated prior to the return of the results, the area shall be delineated for identification purposes.

13. Wood Decks and Surfaces

13.1 Wood deck application shall comply with Section 1521.5 of the *Florida Building Code, Building.*

14. Steel Decks and Surfaces

14.1 All structural steel decks shall be not lighter than 22 ga. unless examined by a professional structural engineer, prior to application, confirming the suitability of application. In addition, a letter shall be provided by the spray applied polyurethane foam manufacturer confirming the specific application is in compliance manufacturer's guidelines. A copy of the structural report and manufacturers letter shall be attached to Section II of the Uniform Building Permit application and submitted to the building official for review.

14.2 Nonstructural metal panels forming the substrate for a spray applied polyurethane foam Roof Assembly shall be not lighter than 24 ga.

14.3 All steel deck joints shall be correctly lapped, fastened and sealed prior to application of spray applied polyurethane foam.

14.4 If an approved insulation board is applied to a fluted deck, the board shall be attached in compliance with RAS 117 and the wind load requirements set forth in Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*. Insulation boards shall be of sufficient dimension to span deck flutes.

15. Concrete Decks and Surfaces

15.1 All concrete shall be free of contaminants and chemical release agents.

15.2 Priming of all concrete surfaces is required. New concrete decks shall have a cure period of not less than 28 days prior to the application of spray applied polyurethane foam.

15.3 All joints greater than $^1/_8$ in. shall be filled or bridged with an acceptable product to the spray applied polyurethane foam manufacturer.

15.4 Spray-applied polyurethane foam shall not be applied to lightweight insulating concrete.

16. Wind Speeds

16.1 Spray-applied polyurethane foam may be applied up to wind speeds of 25 mph if effective wind screens, tenting, robotic equipment, are used to prevent over spray damage and unacceptable surface texture.

17. Coatings

17.1 All coatings shall be approved for use with the spray-applied polyurethane foam Roof Assembly and shall be noted as such in the coating manufacturer's Product Approval and the spray applied polyurethane foam manufacturer's roof assembly Product Approval.

17.2 Coating may be one of the following:

- Acrylics
- Butyls
- Chlorinated synthetic rubbers
- Silicones
- Polyurethanes
- Modified asphalts.

17.3 All coatings shall be in compliance with applicable physical properties noted in Chapter 15 (High-Velocity Hurricane Zone) of the *Florida Building Code, Building* and TAS 110. Additionally, coatings shall be tested for peel strength of the coatings to foam in compliance with TAS 114(H) and RAS 109(A).

17.4 The coatings shall be applied in compliance with coating manufacturer's Product Approval, and spray applied polyurethane foam manufactures Product Approval.

17.5 The base coat, if necessary, shall be applied the same day as the spray applied polyurethane foam. The base coats shall be allowed to cure as specified by the coating manufacturer prior to the application of the final top coat.

17.6 After application of top coating, the surface shall be allowed to fully cure prior to inspection for pin holes, thin coated areas and other defects.

18. Coating Testing

18.1 Slit test samples of a minimum $^1/_2$ in. wide, 2 in. to 3 in. long and least $^3/_4$ in. deep shall be cut at a minimum of one sample every 2,500 ft^2 for visual observation and testing. In addition, one slit sample within ten feet of each drain shall be taken.

18.2 Four thickness measurements shall be taken from each sample.

18.3 Results of the tests shall be provided in the Job Log for review by the building official.

18.4.1 If any samples in the random sampling are determined to be inferior, additional test samples shall be taken at an interval of one sample every 2,500 ft^2 to determine the extent of inferior application.

18.4.2 Any areas found to be inferior shall be recoated following methods published by the component manufacturer and maintained in the Job Log.

19. Walkways

19.1 Walkways, when installed, shall be breathable walk pads approved by the coating manufacturer, and shall be installed and bonded to the coating surface.

20. Perimeter Metal

20.1 All perimeter metal shall be in compliance with RAS 111 for retrofit, reroof and new applications.

21. Final Inspection

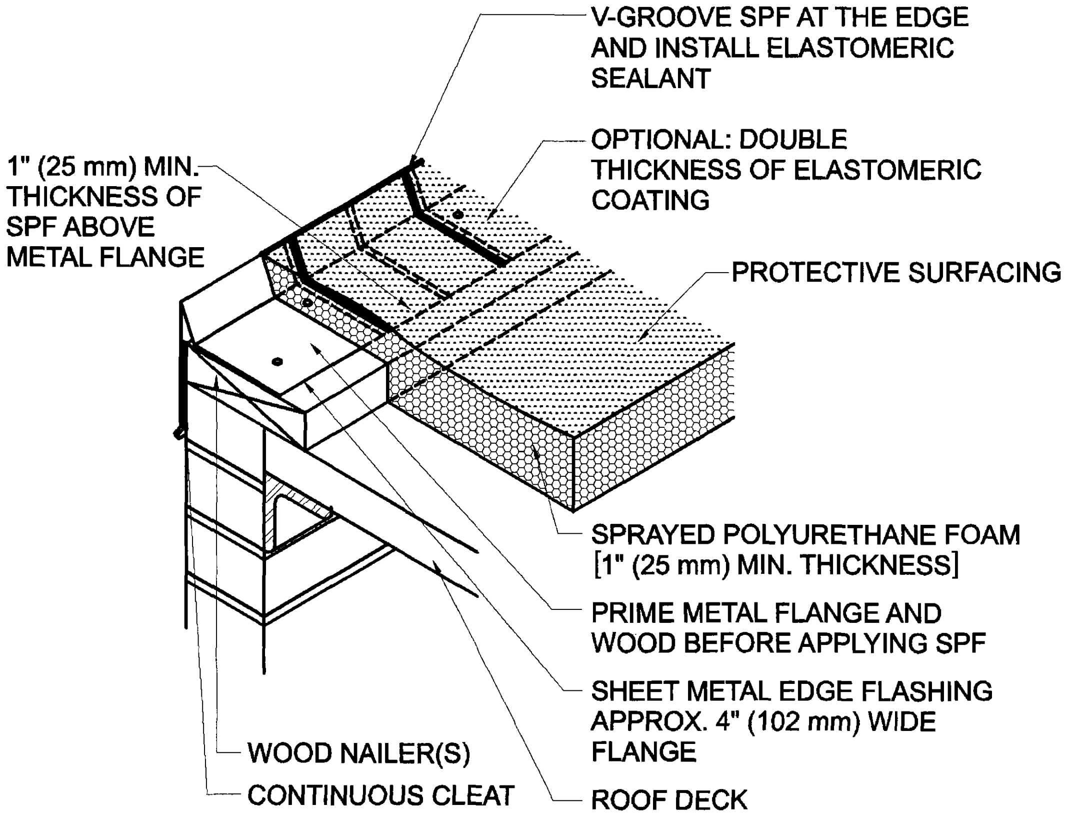
21.1 A final inspection of the completed Roof Assembly shall be conducted by the building official to confirm compliance with the requirements of this Application Standard and the requirements set forth in the *Florida Building Code, Building*.

21.2 A final inspection shall also be conducted by the Roof Assembly manufacturer, or an inspection service designated by the manufacturer, confirming the application is in compliance with the material requirements and application standards established by the manufacturer.

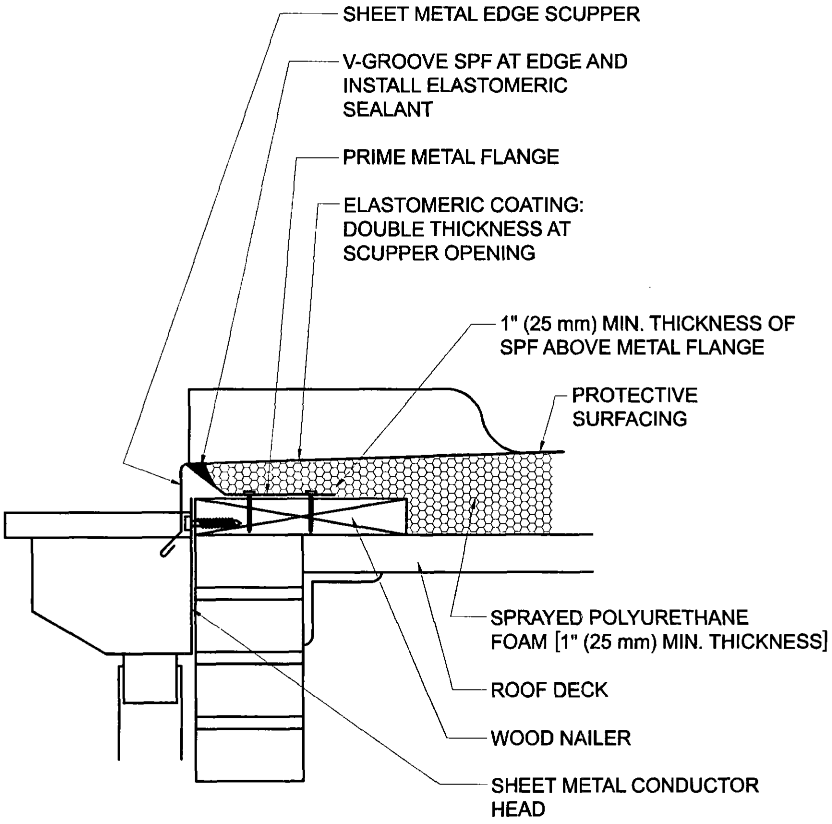
21.3 The Roof Assembly manufacturer shall complete a final inspection certification not later than 30 days after completion of the application, as required in Section 1521.18.2 of the *Florida Building Code, Building*.

ROOFING APPLICATION STANDARD (RAS) No. 109-A
Detail Drawings

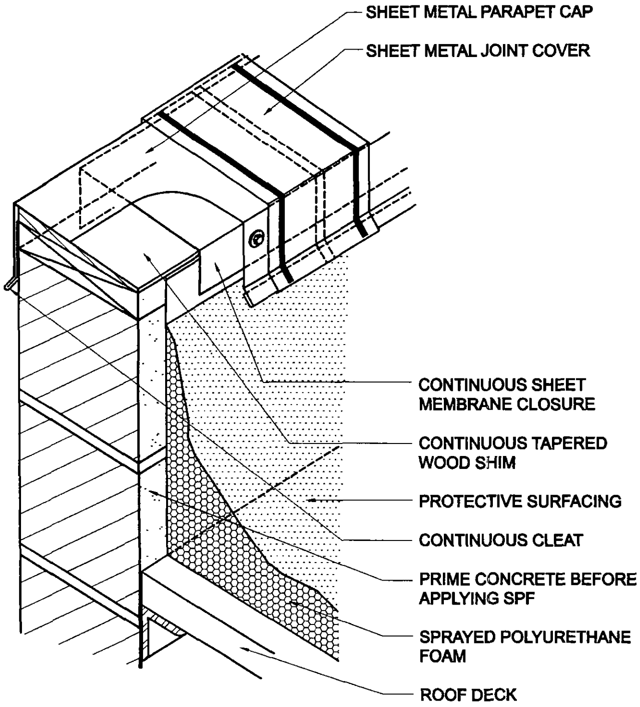
The following guide details have been provided by the Polyurethane Foam Contractors Division of The Society of the Plastics Industry, Inc. for application guidelines.


V-GROOVE SPF AT THE EDGE AND INSTALL ELASTOMERIC SEALANT
OPTIONAL: DOUBLE THICKNESS OF ELASTOMERIC COATING
1" (25 mm) MIN. THICKNESS OF SPF ABOVE METAL FLANGE
PROTECTIVE SURFACING
SPRAYED POLYURETHANE FOAM [1" (25 mm) MIN. THICKNESS]
PRIME METAL FLANGE AND WOOD BEFORE APPLYING SPF
SHEET METAL EDGE FLASHING APPROX. 4" (102 mm) WIDE FLANGE
WOOD NAILER(S)
CONTINUOUS CLEAT
ROOF DECK

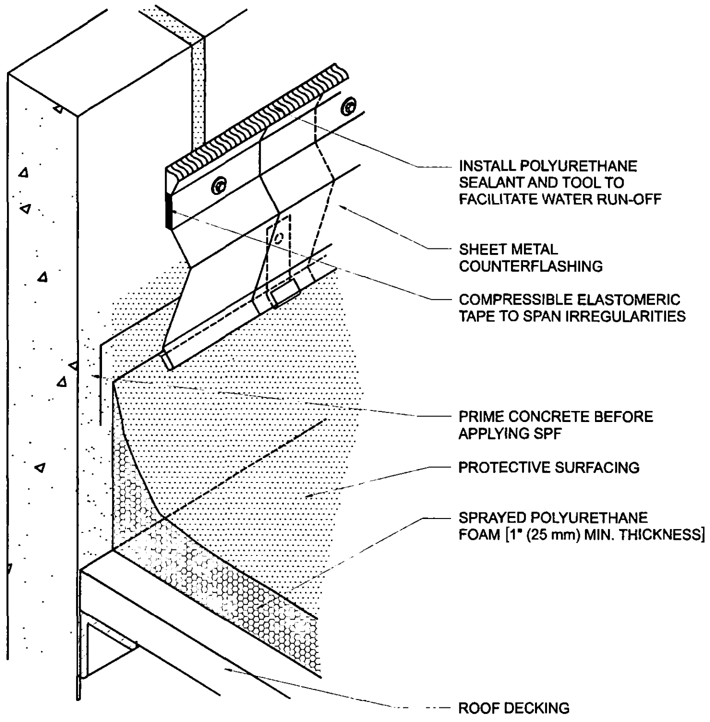
DETAIL 1


SHEET METAL EDGE SCUPPER
V-GROOVE SPF AT EDGE AND INSTALL ELASTOMERIC SEALANT
PRIME METAL FLANGE
ELASTOMERIC COATING: DOUBLE THICKNESS AT SCUPPER OPENING
1" (25 mm) MIN. THICKNESS OF SPF ABOVE METAL FLANGE
PROTECTIVE SURFACING
SPRAYED POLYURETHANE FOAM [1" (25 mm) MIN. THICKNESS]
ROOF DECK
WOOD NAILER
SHEET METAL CONDUCTOR HEAD

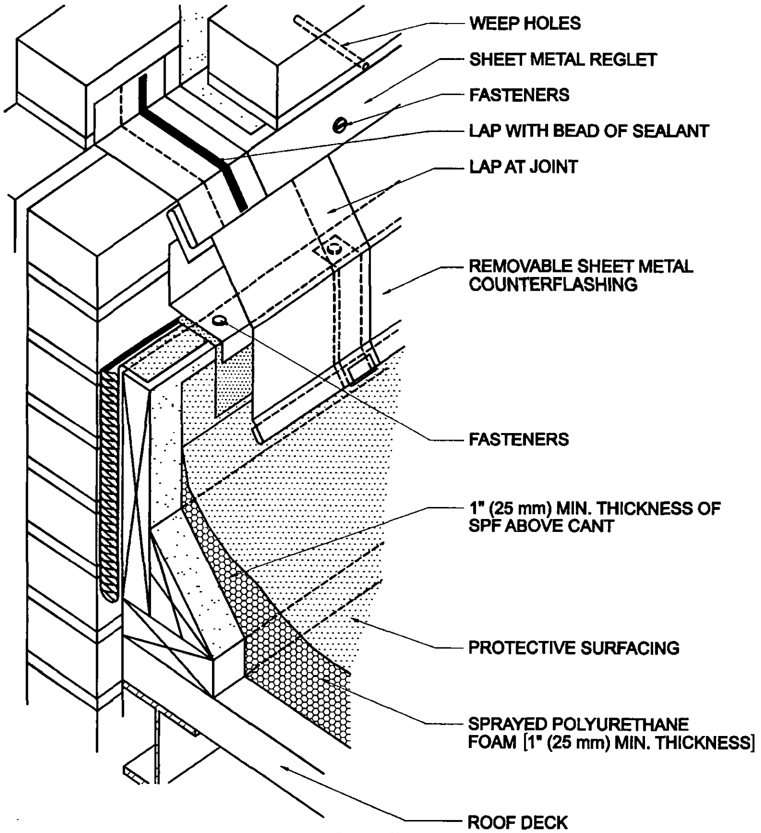
DETAIL 2


SHEET METAL PARAPET CAP
SHEET METAL JOINT COVER
CONTINUOUS SHEET MEMBRANE CLOSURE
CONTINUOUS TAPERED WOOD SHIM
PROTECTIVE SURFACING
CONTINUOUS CLEAT
PRIME CONCRETE BEFORE APPLYING SPF
SPRAYED POLYURETHANE FOAM
ROOF DECK

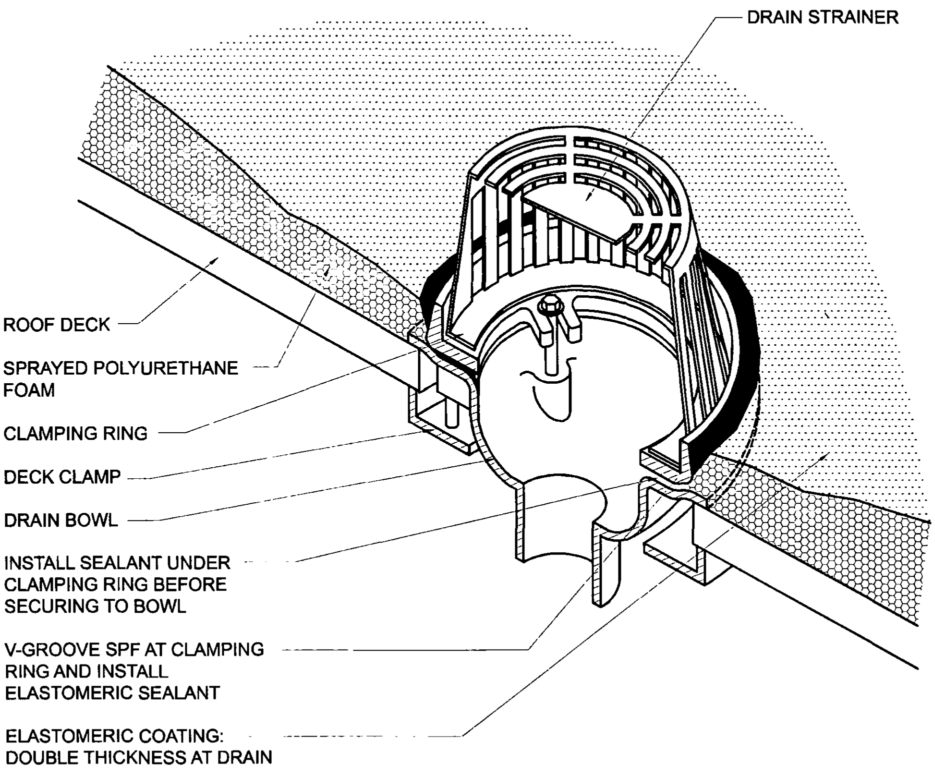
DETAIL 3


INSTALL POLYURETHANE SEALANT AND TOOL TO FACILITATE WATER RUN-OFF
SHEET METAL COUNTERFLASHING
COMPRESSIBLE ELASTOMERIC TAPE TO SPAN IRREGULARITIES
PRIME CONCRETE BEFORE APPLYING SPF
PROTECTIVE SURFACING
SPRAYED POLYURETHANE FOAM [1" (25 mm) MIN. THICKNESS]
ROOF DECKING

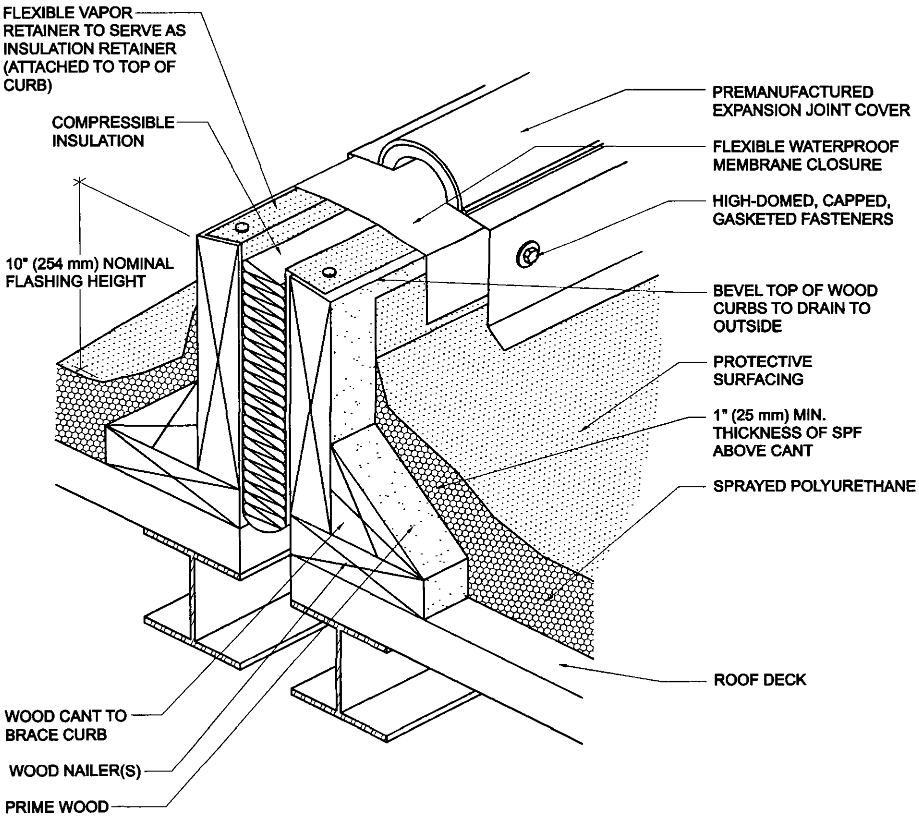
DETAIL 4


WEEP HOLES
SHEET METAL REGLET
FASTENERS
LAP WITH BEAD OF SEALANT
LAP AT JOINT
REMOVABLE SHEET METAL COUNTERFLASHING
FASTENERS
1" (25 mm) MIN. THICKNESS OF SPF ABOVE CANT
PROTECTIVE SURFACING
SPRAYED POLYURETHANE FOAM [1" (25 mm) MIN. THICKNESS]
ROOF DECK

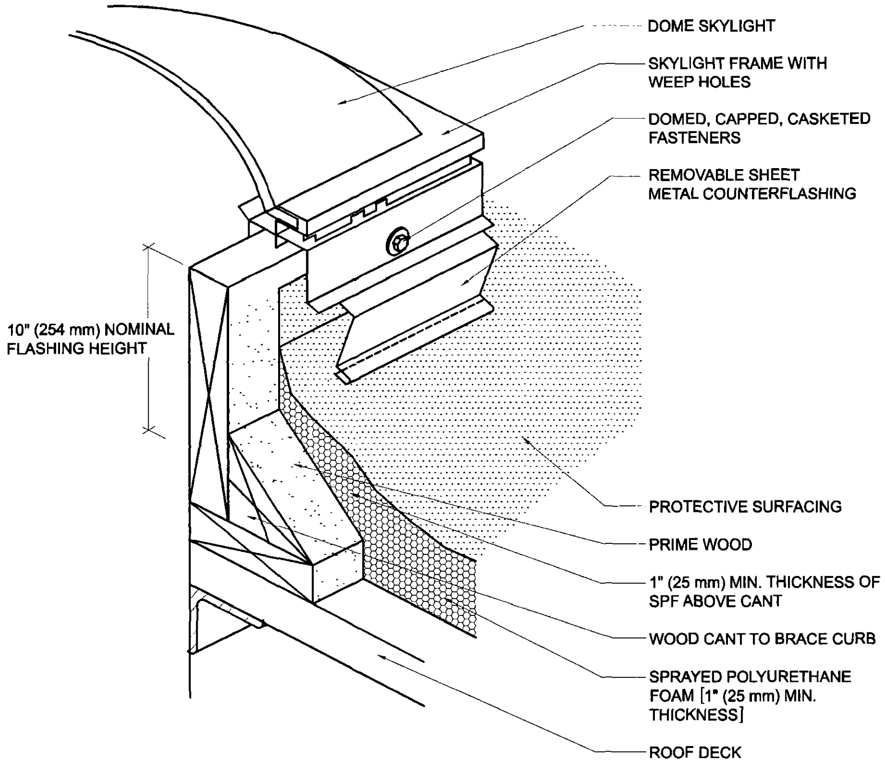
DETAIL 5


DRAIN STRAINER
ROOF DECK
SPRAYED POLYURETHANE FOAM
CLAMPING RING
DECK CLAMP
DRAIN BOWL
INSTALL SEALANT UNDER CLAMPING RING BEFORE SECURING TO BOWL
V-GROOVE SPF AT CLAMPING RING AND INSTALL ELASTOMERIC SEALANT
ELASTOMERIC COATING: DOUBLE THICKNESS AT DRAIN

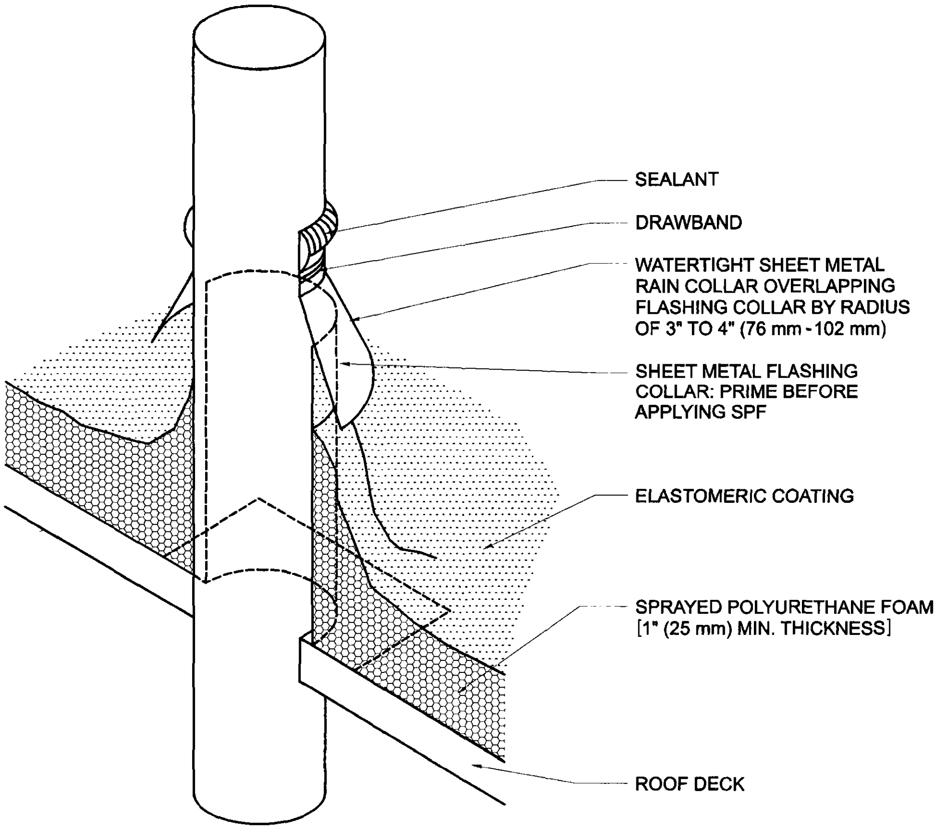
DETAIL 6


FLEXIBLE VAPOR RETAINER TO SERVE AS INSULATION RETAINER (ATTACHED TO TOP OF CURB)
COMPRESSIBLE INSULATION
10" (254 mm) NOMINAL FLASHING HEIGHT
PREMANUFACTURED EXPANSION JOINT COVER
FLEXIBLE WATERPROOF MEMBRANE CLOSURE
HIGH-DOMED, CAPPED, GASKETED FASTENERS
BEVEL TOP OF WOOD CURBS TO DRAIN TO OUTSIDE
PROTECTIVE SURFACING
1" (25 mm) MIN. THICKNESS OF SPF ABOVE CANT
SPRAYED POLYURETHANE
ROOF DECK
WOOD CANT TO BRACE CURB
WOOD NAILER(S)
PRIME WOOD

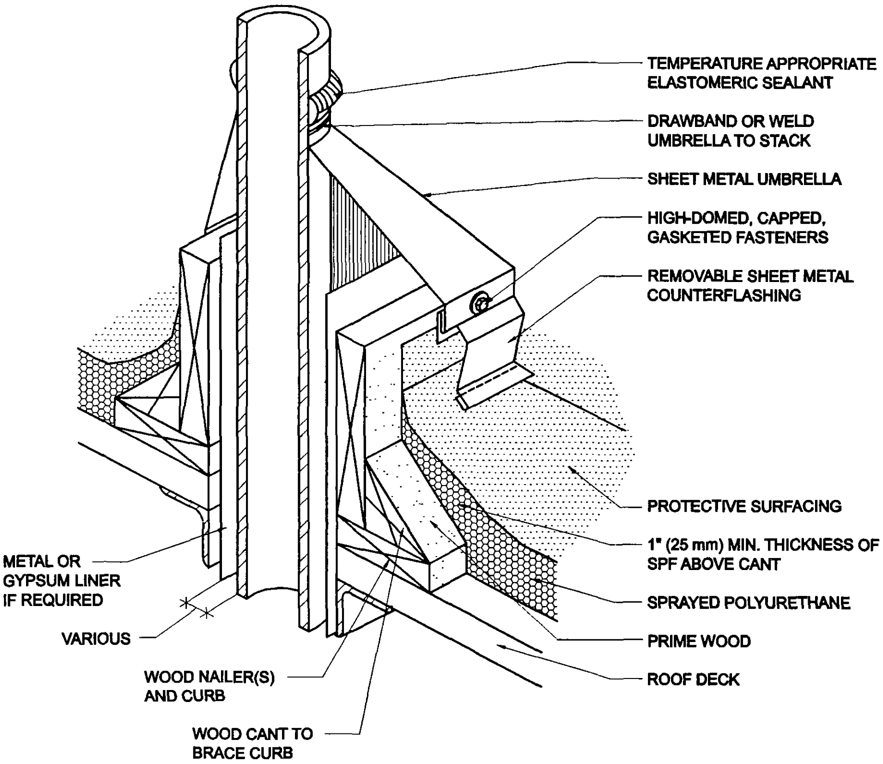
DETAIL 7


DOME SKYLIGHT
SKYLIGHT FRAME WITH WEEP HOLES
DOMED, CAPPED, CASKETED FASTENERS
REMOVABLE SHEET METAL COUNTERFLASHING
10" (254 mm) NOMINAL FLASHING HEIGHT
PROTECTIVE SURFACING
PRIME WOOD
1" (25 mm) MIN. THICKNESS OF SPF ABOVE CANT
WOOD CANT TO BRACE CURB
SPRAYED POLYURETHANE FOAM [1" (25 mm) MIN. THICKNESS]
ROOF DECK

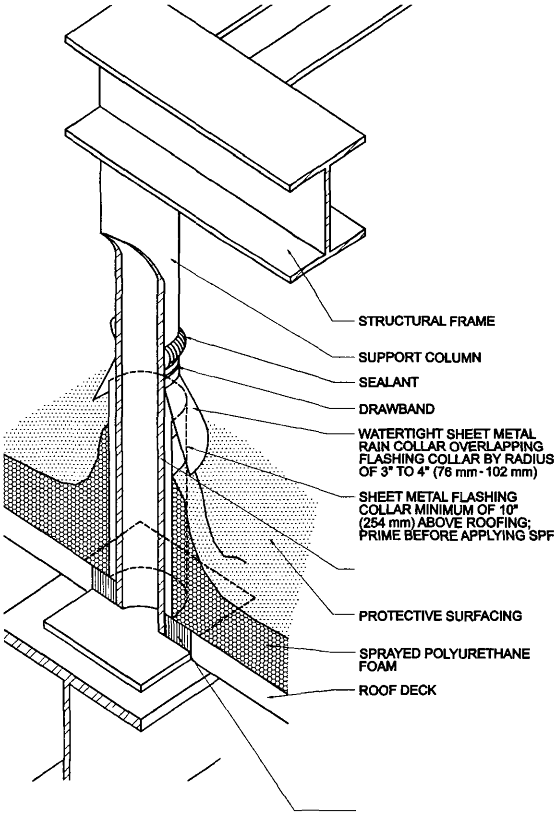
DETAIL 8


SEALANT
DRAWBAND
WATERTIGHT SHEET METAL RAIN COLLAR OVERLAPPING FLASHING COLLAR BY RADIUS OF 3" TO 4" (76 mm - 102 mm)
SHEET METAL FLASHING COLLAR: PRIME BEFORE APPLYING SPF
ELASTOMERIC COATING
SPRAYED POLYURETHANE FOAM [1" (25 mm) MIN. THICKNESS]
ROOF DECK

DETAIL 9


TEMPERATURE APPROPRIATE ELASTOMERIC SEALANT
DRAWBAND OR WELD UMBRELLA TO STACK
SHEET METAL UMBRELLA
HIGH-DOMED, CAPPED, GASKETED FASTENERS
REMOVABLE SHEET METAL COUNTERFLASHING
PROTECTIVE SURFACING
1" (25 mm) MIN. THICKNESS OF SPF ABOVE CANT
SPRAYED POLYURETHANE
PRIME WOOD
ROOF DECK
METAL OR GYPSUM LINER IF REQUIRED
VARIOUS
WOOD NAILER(S) AND CURB
WOOD CANT TO BRACE CURB

DETAIL 10


STRUCTURAL FRAME
SUPPORT COLUMN
SEALANT
DRAWBAND
WATERTIGHT SHEET METAL RAIN COLLAR OVERLAPPING FLASHING COLLAR BY RADIUS OF 3" TO 4" (76 mm - 102 mm)
SHEET METAL FLASHING COLLAR MINIMUM OF 10" (254 mm) ABOVE ROOFING; PRIME BEFORE APPLYING SPF
PROTECTIVE SURFACING
SPRAYED POLYURETHANE FOAM
ROOF DECK

DETAIL 11

ROOFING APPLICATION STANDARD (RAS) No. 111
STANDARD REQUIREMENTS FOR ATTACHMENT OF PERIMETER WOODBLOCKING AND METAL FLASHING

1. Scope

1.1 This Application Standard provides:1) the minimum criteria for attachment of perimeter and termination woodblocking; and 2) the minimum criteria for material fabrication and attachment of perimeter metal flashing.

2. Definitions

2.1. For definitions of terms used in this application standard, refer to ASTM D 1079; and the *Florida Building Code, Building.*

3. Woodblocking Attachment

3.1. Wood blocking shall be attached to resist wind forces, and other loads, as required by Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

3.2 Fastener value (f_V)

3.2.1 Fasteners/anchors which have published withdrawal resistance values, generated from laboratory testing, shall have a margin of safety, as noted in Table 1, below, applied to average laboratory test results.

- Use of published withdrawal resistance values to determine a fastener value for a particular application shall be contingent upon the similarity of substrate materials which generated the published values in comparison to the substrate material of the actual application.

3.2.2 Alternatively, the Fastener Value may be the result of in situ (on-site) testing, in compliance with TAS 105, resulting in a minimum characteristic resistance force which shall be used as the Fastener Value.

TABLE 1
MARGINS OF SAFETY FOR LABORATORY WITHDRAWAL RESISTANCE TESTING

Substrate	Margin of Safety
Steel Decking	2:1
Concrete Decking	4:1
Wood Decking	2:1
Gypsum Decking	3:1
Cementitous Wood Fiber Decking	3:1
Structural Steel	2:1

3.3 Woodblocking Fastener Spacing

3.3.1 The attachment criteria for woodblocking shall be 250 plf for perimeter areas and 300 plf for corner areas.

3.3.2 In any event, woodblocking fastener spacing shall not exceed 18 in. o.c.

3.4 Woodblocking attachment, general requirements:

3.4.1 In recover, or residential wood decks applications, woodblocking thickness may be reduced to 1 in., provided the attachment is in compliance with the provisions of Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

3.4.2 The maximum unsupported overhang of the woodblocking shall not exceed 2 in. If the maximum overhang is employed, the minimum woodblocking dimensions shall be not less than a nominal 2 in. by 8 in. and two rows of fasteners shall be installed in a staggered manner.

3.4.3 A fastener shall be placed within 3 in. of the end of each section of woodblocking, and a $^1/_4$ in. gap shall be left between each section of woodblocking.

3.4.4 All fastener/anchor heads shall be countersunk or fastener/anchor heads shall be driven flush with the top surface of the woodblocking.

3.4.5 All woodblocking, shall be only salt pressure treated in accordance with the American Wood Preservers Association, C-2 or C-9, or any decay resistant species.

3.4.6 If the woodblocking thickness is greater than that of the insulation a tapered edge shall be installed to create a sloped transition between the insulation and the woodblocking.

3.4.7 All fasteners/anchors used for attachment of woodblocking shall meet the corrosion resistance requirements set forth in Appendix 'E' of TAS 114 for insulation and membrane fasteners (DIN 50018).

3.4.8 When the width of the woodblocking is greater than 6 in. anchors shall be staggered in two rows across the woodblocking width.

3.5 Woodblocking Attachment, Masonry Block

3.5.1 When the masonry block is cast with lightweight aggregate, anchor bolts shall be embedded not less than 6 in. into the second course of block.

3.5.2 If expansion bolts are substituted for $^1/_2$ in. diameter cast in place anchor bolts, the minimum expansion bolt diameter shall be $^3/_8$ in.

3.6 Woodblocking Attachment, Structural Concrete

3.6.1 Anchors used for woodblocking attachment to structural concrete shall have a nominal diameter of 0.250 in.; therefore, a threaded concrete anchor or insulation fastener with a nominal $^1/_4$ in. diameter shall be acceptable.

3.6.2 Powder actuated (PAT) fastening (Pins and Loads) shall not be an acceptable method of attachment.

3.7 Woodblocking Attachment, Steel Decking

3.7.1 All fasteners shall penetrate the top flange of the steel deck.

3.7.2 When woodblocking is attached parallel to the deck flutes, the steel decking shall be mechanically attached to the structural steel with minimum $^1/_4$ in. diameter self-tapping or self-drilling fasteners with a minimum $^5/_8$ in. diameter bearing washer, at a maximum spacing of seven feet o.c. prior to the attachment of the woodblocking.

3.7.3 If the steel deck thickness is less than 22 gage, a withdrawal resistance test, in compliance with TAS 105, shall be conducted to determine compliance with Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

3.8 Woodblocking Attachment, Lightweight Decks

3.8.1 For the purposes of this section, 'lightweight decks' shall include gypsum, cementitious woodfiber and lightweight insulating concrete decks.

3.8.2 Lightweight decks should not be used as a woodblocking attachment substrate unless:

- The selected woodblocking anchor is fastened to the underside of the deck or attached directly to a structural member.
- The selected woodblocking anchor can achieve an average withdrawal resistance of not less than 450 lbf tested in compliance

with TAS 105.

3.8.3 Toggle bolts are not acceptable woodblocking fasteners for any type deck.

3.8.4 Fastener spacing for wood blocking shall not exceed 12 inches o.c.

4. Galvanic Action

4.1 Components shall be compatible to minimize the potential for galvanic corrosion. Galvanic corrosion will occur when dissimilar metals come into contact with an electrolyte. An electrolyte is any nonmetallic substance (especially liquid) that will conduct electric current. Water is an electrolyte. Metals that are more electro-positive (anodic or least noble) and will corrode more easily are at one end of the scale. Those that are more electro-negative (cathodic are more 'noble') and are more corrosion resistant are at the other end of the scale.

4.2 Common metals used in metal roof construction in order of least noble to more noble are as follows:

- Anodic (least noble)
- Magnesium
- Magnesium Alloys
- Zinc
- Galvanized Coated Steel
- Aluminum 1100
- Alclad
- Cadmium
- Mild Steel
- Wrought Iron
- Cast Iron
- 13 percent Chromium Stainless Steel (Type 410 active.)
- 18-8 Stainless Steel (Type 304 active.)
- 18-12-3 Stainless Steel (Type 316 active.)
- Lead / Tin Solder
- Lead
- Tin
- Muntz Metal
- Manganese Bronze
- Naval Brass
- Nickel (active)
- 76 Ni-16 Cr-7 Fe alloy (active)
- 60 Ni-30 Mo-6 Fe-1 Mn
- Yellow Brass
- Admiralty Brass
- Aluminum Brass
- Red Brass
- Copper
- Silicone Bronze
- 70:30 Cupro Nickel
- G-Bronze
- M-Bronze
- Silver Solder
- Nickel (passive)
- 76 Ni-16 Cr-7 Fe alloy (passive)
- Monel
- 13 % Chromium Stainless Steel (Type 410 passive)
- Titanium
- 18-8 Stainless Steel (Type 304 passive)
- 18-12-3 Stainless Steel (Type 316 passive)
- Silver
- Graphite
- Gold
- Platinum
- Cathodic (more noble)

4.3 To reduce the occurrence of galvanic corrosion, the following steps shall be taken:

- Do not place metals far apart in the scale in contact with each other. Fasteners shall be of compatible materials.
- The more noble (cathodic) metal may be coated with a suitable paint or non-metallic coating.
- Do not design drainage from a cathodic to anodic metal even if materials do not make contact. The water will conduct electrical current between the two materials.
- Galvanized nails shall not be used to attach copper metal.

4.4 Flashing gages:

4.4.1 Table 2 lists material thickness requirements based on edge metal component dimensions for roof mean

TABLE 2
HOOK STRIP/CONTINUOUS CLEAT THICKNESS REQUIREMENTS FOR EDGE METAL AND COPINGS FACE DIMENSIONS

GALVANIZED METAL OR STAINLESS STEEL						
Min. Component Gage		26 ga	24 ga	22 ga	20 ga	18 ga
Max. Vertical (Face) Flange		4 in.	6 in.	8 in.	10 in.	12 in.
Min. Hook Strip/Cleat Gage[1]		24 ga	22 ga	20 ga	18 ga	16 ga
ALUMINIM						
Min. Component Gage	0.032 in.	0.032 in.	0.040 in.	0.050 in.	0.060 in.	0.070 in.
Max. Vertical (Face) Flange	< 3 in.	3 in.	4 in.	6 in.	8 in.	10 in.
Min. Hook Strip/Cleat Gage	Not Required	0.040 in.	0.050 in.	0.060 in.	0.070 in.	0.080 in.
COPPER						
Min. Component Gage			16 oz	20 oz.	24 oz.	32 oz
Max. Vertical (Face) Flange			3.5 in.	6 in.	8 in.	10 in.
Min. Hook Strip/Cleat Weight[1]			20 oz.	24 oz.	32 oz	48 oz

For SI: 1 inch = 25.4 mm.

[1] Hook strip shall be one thickness greater than that of the metal profile material, as commercially available.

height less than 54 ft. For roof mean height of 54 ft. or greater flashing terminations shall be designed by a professional engineer or registered architect proficient in roofing design. Calculations in compliance Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* shall be submitted with Section II of the Uniform Building Permit Application to the building official for review.

4.4.2 All edge metal profiles, copings, and coping caps shall comply with Table 2 herein. The maximum vertical (face) dimension listed in Table 2 represents the vertical (face) dimensions where a hook strip is required. Smaller vertical (face) dimension than those listed in Table 2 edge metal profiles and copings of the specified gauge may be used without a hook strip.

5. Drip Edge and Gravel Stop

5.1 Minimum attachment shall include horizontal flange attachment with approved minimum 12 ga. annular ring shank nails at a spacing not to exceed 4 in. o.c. in a staggered pattern. Rows shall be approximately $^{3}/_{4}$ in. to 1 in. from each edge of the horizontal flange. Nails shall be fabricated from similar or compatible material to the drip edge/gravel stop.

5.2 Installation requirements:

5.2.1 Vertical flange dimensions shall be not less than $1^{1}/_{2}$ in. and the horizontal dimension shall not be less than 2 in. wide. The vertical flange shall be of sufficient length to extend below the sheathing or other member immediately contiguous thereto by not less than $^{1}/_{2}$ in. Table 2 herein lists maximum vertical flange dimensions for various drip edge/gravel stop materials.

5.2.2 Drip edge/gravel stop shall be fabricated in lengths not greater than 12 feet. Sections may be joined by one of the two following methods:

- ***"Butt-Joint" Method:*** Drip edge/gravel stop sections shall be installed with a $^1/_4$ in. to $^1/_2$ in. gap between each section to allow for expansion and contraction of the metal. A back or cover plate shall be installed at each joint with approved sealant applied between the edge component and the back or cover plate.

- ***"Overlap" Method:*** Drip edge/gravel stop sections shall be installed with a minimum 4 in. overlap between each section with a bed of approved sealant at each overlap. Overlaps are to be installed to ensure water shedding capabilities at rakes/gables.

5.2.3 When a continuous cleat (hook strip) is required and the vertical flange exceeds 7 in. the "butt-joint" method shall be utilized and a cover plate shall be installed.

NOTE: All metal surfaces receiving hot bitumen approved flashing cement shall be fully primed with ASTM D 41 or ASTM D 43, as required, primer. Primer which is in a quick dry formulation is acceptable. All fasteners shall be covered with either:

- Two layers of "stripping" or "flashing" felt set in hot asphalt or approved flashing cement; or,
- A single layer of modified bitumen, torch applied or set in hot asphalt, or approved adhesive.

Exception: Drip edge for asphalt shingle roof systems need not comply with this section.

5.2.4 The continuous cleat (hook strip) minimum attachment installation shall be as follows:

- The cleat shall be attached to the vertical face of the woodblocking or structure using approved 12 ga annular ring shank nails or # 10 diameter fasteners spaced not greater than 10 in. o.c. at perimeter roof areas and 6 in. o.c. at corner roof areas.

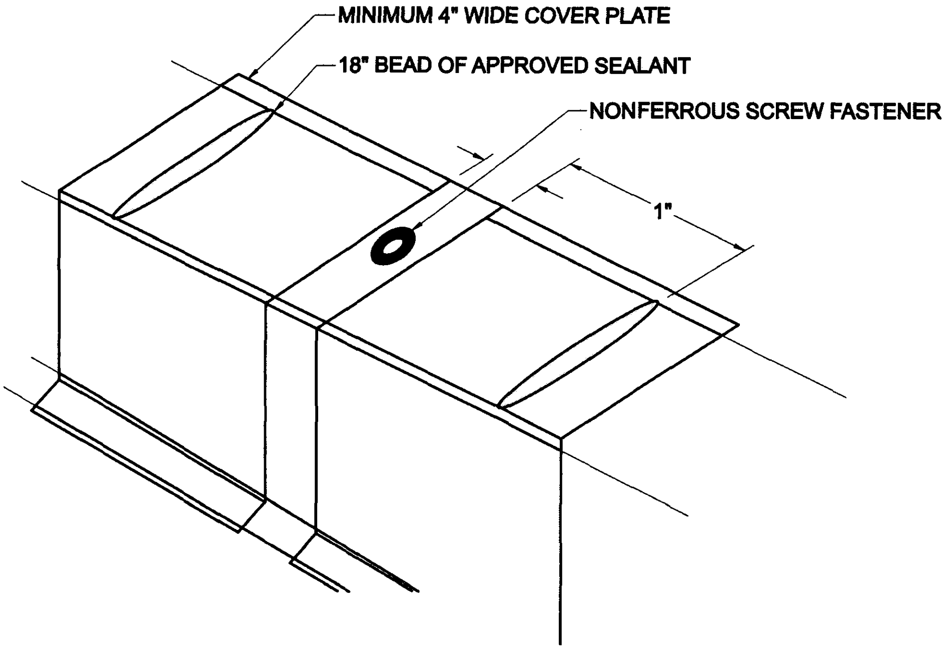

MINIMUM 4" WIDE COVER PLATE
18" BEAD OF APPROVED SEALANT
NONFERROUS SCREW FASTENER
1"

FIGURE 1
DETAIL OF "BUTT-JOINT" METHOD FOR ADJACENT DRIP EDGE/GRAVEL STOP SECTIONS

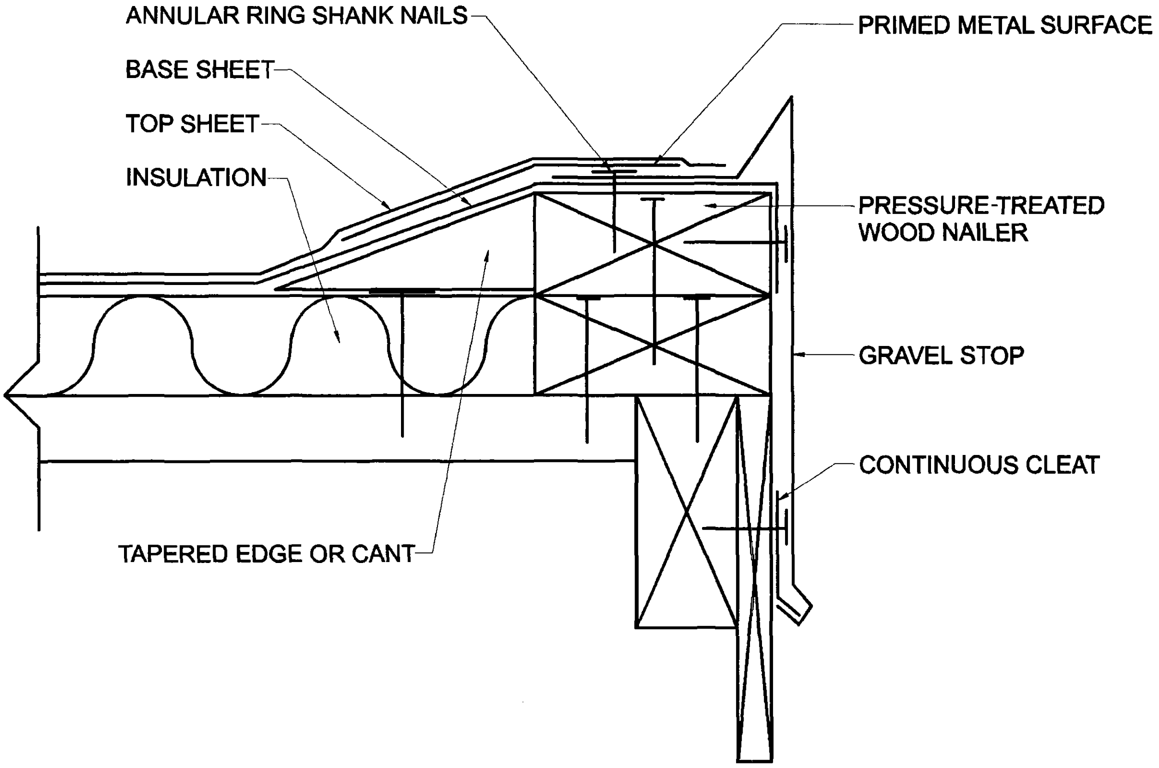


FIGURE 2
EXAMPLE OF RAISED EDGE AT GRAVEL STOP PERIMETER FLASHING

- Nails shall be fabricated from similar or compatible material to that of the continuous cleat, and shall be of sufficient length to penetrate the substrate by not less than 1¼ in. and shall have a minimum head size of $^5/_{16}$ in.

- Nylon or plastic anchors shall not be acceptable.

5.2.5 Notwithstanding the minimum attachment criteria noted herein, metal edge systems of any dimension may be tested in compliance with TAS 111(A) and TAS 111 (B), the values from which may be submitted with Section II of the Uniform Building Permit application to the building official for review.

5.2.6 Heavy, extruded drip edge/gravel stop sections may be used provided a horizontal flange of a lesser thickness is incorporated into the edge metal configuration (see Figure 4).

5.2.7 Where the drip edge/gravel stop forms part of a metal roof system, the following provisions apply:

- The drip edge/gravel stop shall be secured to the profile metal sheetor structural members with sufficient anchors/fasteners to resist wind forces determined in compliance with Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* and in accordance with RAS 111and 133.

- All fasteners shall be fitted with minimum $^5/_8$ in. o.c.bonded sealing washers, unlessotherwise noted in the roofing assembly Product Approval.

- Continuous clips (hook strips) shall be required as noted in Table 2 herein.

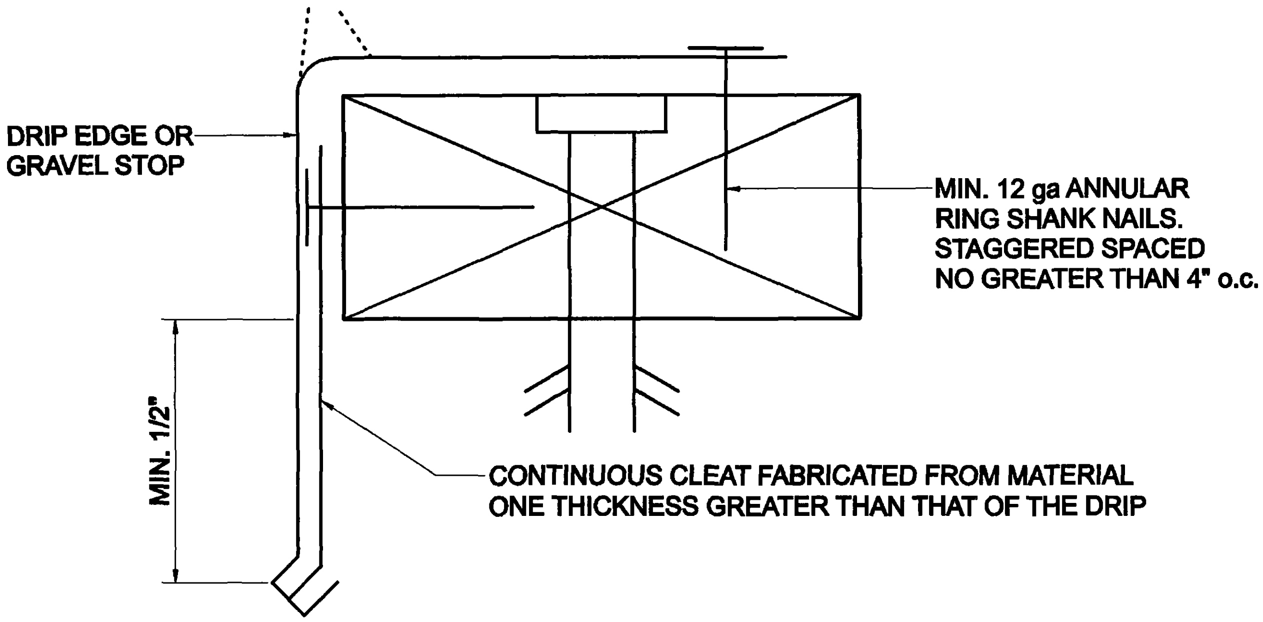

DRIP EDGE OR GRAVEL STOP
MIN. 12 ga ANNULAR RING SHANK NAILS. STAGGERED SPACED NO GREATER THAN 4" o.c.
MIN. 1/2"
CONTINUOUS CLEAT FABRICATED FROM MATERIAL ONE THICKNESS GREATER THAN THAT OF THE DRIP

FIGURE 3
EXAMPLE OF A PERIMETER FLASHING FOR CONFIGURATIONS INCLUDING A CONTINUOUS CLEAT

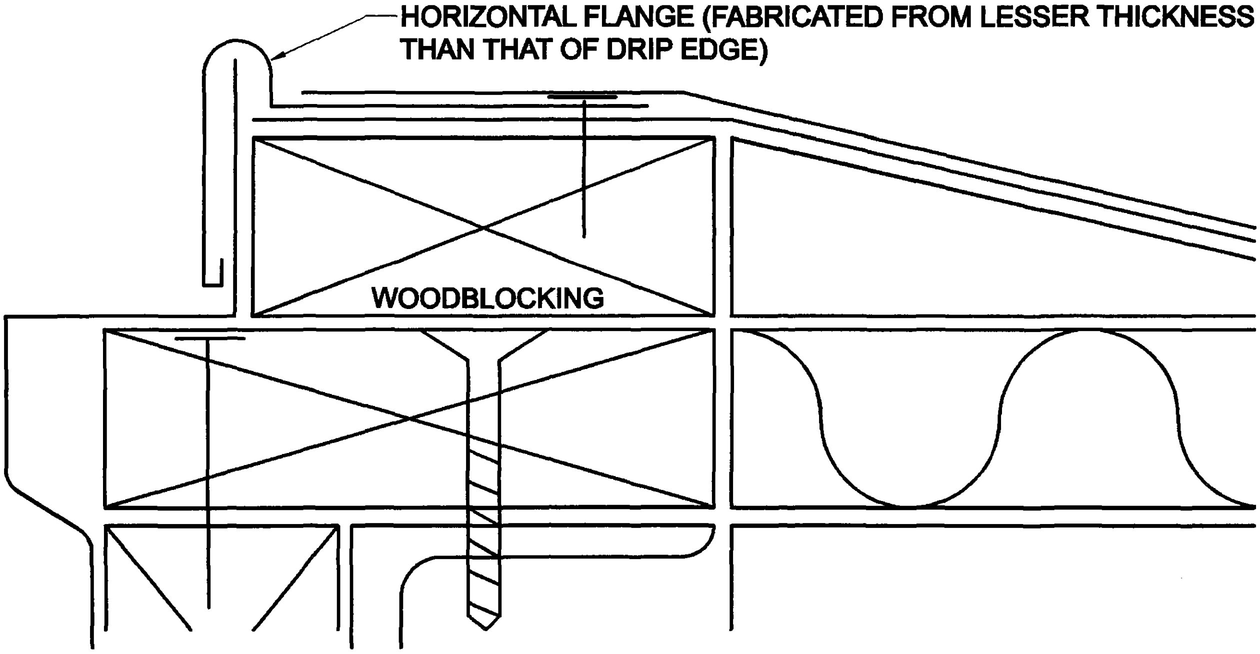

HORIZONTAL FLANGE (FABRICATED FROM LESSER THICKNESS THAN THAT OF DRIP EDGE)
WOODBLOCKING

FIGURE 4
USE OF HEAVY EXTRUDED GRAVEL STOP WITH HORIZONTAL FLANGE OF LESSER THICKNESS

6. Metal Profiles, Copings, & Coping Caps

6.1 All metal profiles, copings, and coping cap attachments must resist wind induced outward and upward forces which attempt to lift or peel the edge system from its attachment points, in compliance with Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

6.2 The metal profiles, copings, and coping caps and their attachments shall be designed to meet design pressures in compliance with Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* and shall be tested in compliance with TAS 111(A), TAS 111(B) and TAS 111C to confirm compliance.

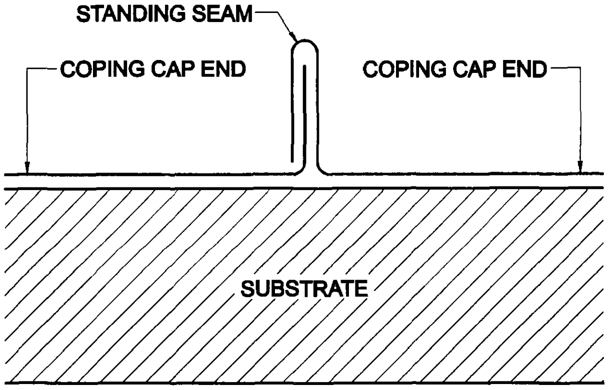
6.2.1 Criteria for vertical flange dimension, material type, thickness, and requirements for use of a continuous cleat (hook strip) are noted in Table 2 herein.

6.3 Installation Requirements

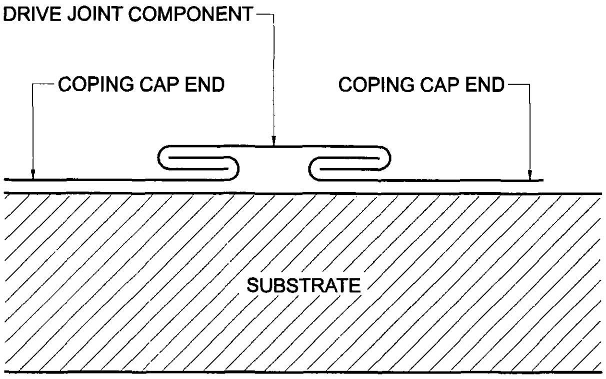
6.3.1 The vertical flange of metal profiles and coping caps shall be of sufficient length to extend below wood blocking by not less than $^1/_2$ in.

6.3.2 At corners, metal profiles, copings, and coping caps may be formed, mitered, lapped, notched, sealed, welded or soldered as necessary to provide a continuous system that is not more susceptible to leaks than straight sections.

6.3.3 Notwithstanding other requirements set forth in this application standard, one said fastener shall be installed not more than 1 in. from the end of each metal profile section where sections are joined with a splice plate.



6.3.4 For metal profiles copings and coping cap applications which require a continuous cleat (hook strip), minimum attachment requirements are as follows:



- The cleat shall be attached to the vertical face of the woodblocking using approved 12 ga. annular ring shank nails or # 10 diameter fastener spaced not greater than 10 in. o.c. at perimeter roof areas and 6 in. o.c. at corner roof areas.

- Nails shall be fabricated from similar or compatible material to that of the continuous cleat, shall be of sufficient length to penetrate the substrate by not less than 1 $^1/_4$ inches (32 mm) and shall have a minimum head size of $^5/_{16}$ in.

- Nylon or plastic anchors shall not be acceptable.

6.4 Coping Caps

6.4.1 Coping caps shall slope toward the roof.

6.4.2 Coping caps shall be fabricated in lengths not greater than 12 feet. Sections may be joined as described above or using one of the following configurations which eliminate splice plates and overlaps.

6.4.2.1 Standing Seam Configuration

6.4.2.2 The Drive Configuration below allows use of a thinner material for the drive joint components than that of the coping sections.

7. Counter-flashing

7.1 For material and thickness requirements see Table 2 herein. Alternatively, counter-flashing manufacturers may obtain Product Approval.

7.2 General Attachment Requirements

7.2.1 Joints in counter-flashings shall be overlapped a minimum of 4 in. or as stated in counter-flashing Product Approval. Corners shall be mitered and soldered or sealed with an approved sealant. At corners, counter-flashings may be formed, mitered, lapped, notched, sealed, welded or soldered as necessary to provide a continuous system that is not more susceptible to leaks than straight sections.

7.2.2 Counter-flashing attachment points shall be elevated not less than 8 in. above the finished roof surface. Where existing job conditions do not allow counter flashing to be 8 in. above finished roof surface, the counter flashing may terminate 4 in. above the finished roof surface. Parapets less that 8 in. above finished roofing must be flashed to the outside edge and include a metal flashing which extends minimum 1 in. below the finished exterior system.

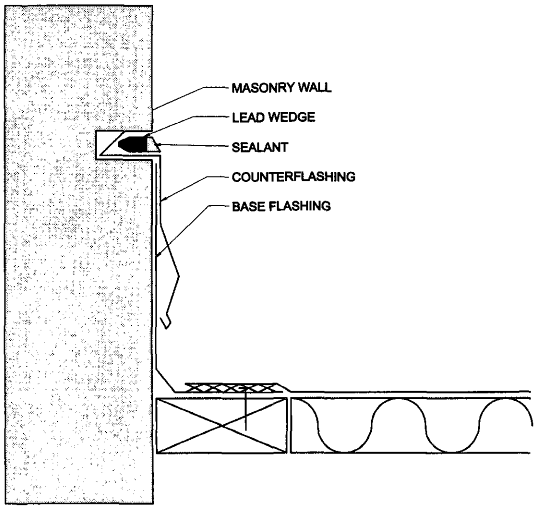


FIGURE 5
EXAMPLE OF REGLET MOUNTED COUNTER-FLASHING

7.2.3 The lower edge of a counter-flashing shall be not less than 1 in. above the top edge of the cant or, when no cant is present, the finished roof surface.

7.2.4 Counter-flashing shall not be a continuous piece across moving wall joints.

7.2.5 Anchors shall provide a minimum characteristic resistance force of 150 lbf, tested in compliance with TAS 105 or an average withdrawal resistance of 150 lbf resulting from laboratory testing after a 2:1 margin of safety is applied. Anchors shall be fitted with a minimum $^5/_8$ in. o.d. bonded sealing washer, having a minimum 0.060 in. gasket thickness, and shall be installed through slotted or oversized holes at a spacing not greater than 8 inches (203 mm) o.c.

7.2.6 Surface mounted flashing shall have a flat surface for flush wall mounting of not less than 1½ in. and not greater than 2½ in. The flashing profile may include stiffening bends at top and bottom. The total of the two bends shall exceed 90 degrees.

7.2.6.1 When an expansion joint occurs at a base flashing, additional counter-flashing attachment shall include:

- A mechanical lock at a two piece reglet; or,
- A reinforcing bar, of similar or compatible material, at the mechanical attachment point to distribute load.

7.3 Reglet-mounted counter-flashings:

7.3.1 If a reglet-mounted counter-flashing is to be used, the joint shall be in accordance with reglet counter-flashing manufacturer's recommendations.

The counter-flashing may be held in place by spring action wedges and sealant. Reglets shall not be cut into hollow cells of masonry walls or concrete.

7.4 For surface mounted reglet-type counter-flashing applications, the following provisions shall apply.

7.4.1 A bead of approved sealant shall be applied at the top edge to create a waterproof seal. Sealant shall be installed in accordance with the sealant manufacturers published literature. Primer shall be applied to the substrate material when recommended by the sealant manufacturer. Sealant shall have two-point adhesion; to the reglet and to the wall substrate for maximum sealant performance. Bond breaker or backer rod shall be installed where necessary to create two-point adhesion. Refer to the sealant manufacturer's published literature for specific types of bond breaker of backer rods.

7.5 Stucco Counter-flashing

7.5.1 Stucco counter-flashing, or "stucco stops," may be fabricated in one- or two-piece configurations or may have Product Approval as a roofing component.

7.5.2 Material thickness and dimension requirements shall comply with Table 2. Alternatively, counter-flashing manufacturers may obtain Product Approval.

7.5.3 Stucco counter-flashing shall be overlapped a minimum of 4 in. or as stated in counter-flashing Product Approval.

7.5.4 Attachment requirements:

7.5.4.1 Anchors shall provide a minimum characteristic resistance force of 100 lbf, tested in compliance with TAS 105 or an average withdrawal resistance of 100 lbf resulting from laboratory testing after a 2:1 margin of safety is applied. Anchors shall be fabricated from similar or compatible material to that of the stucco counter-flashing and shall be installed through slotted or oversized holes at a spacing not greater than 12 in.

7.5.4.2 Where the stucco counter-flashing is attached to steel or wood

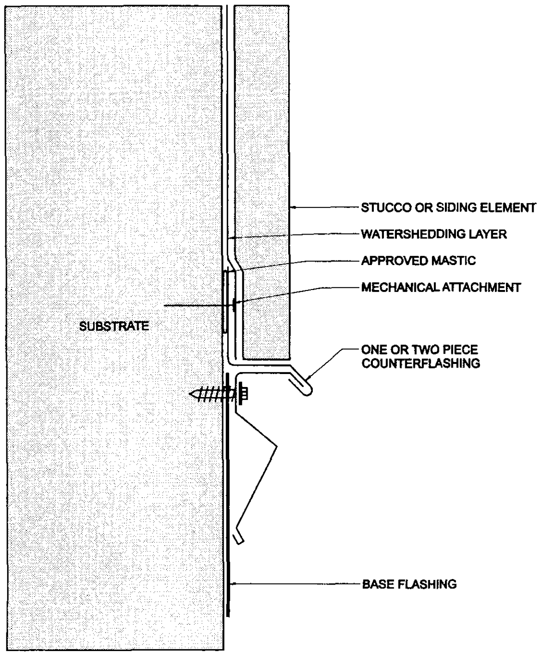


FIGURE 6
EXAMPLE OF STUCCO COUNTER-FLASHING

studs, attachment shall be at each stud with a minimum #8 diameter fastener providing a minimum characteristic resistance force of 150 lbf, tested in compliance with TAS 105 or an average withdrawal resistance of 150 lbf resulting from laboratory testing after a 2:1 margin of safety is applied.

7.5.5 Stucco counter-flashing attachment points shall be elevated not less than 8 in. above the finished roof surface. Where existing job conditions do not allow stucco counter flashing to be 8 inches above finished roof surface, the counter flashing may terminate 4 in. above the finished roof surface. Parapets less than 8 in. above finished roofing must be flashed to the outside edge and include a metal flashing which extends minimum 1 in. below the finished exterior system.

7.5.6 The base water shedding layer behind the stucco or siding element, where required, shall terminate over top of the vertical leg of the stucco counter-flashing. Vertical leg of the stucco counter-flashing shall be set in a bed of approved mastic prior to mechanical attachment or sealed in a three course application of asphalt based mastic and minimum 4 in. wide fiberglass membrane following mechanical attachment (see Figure 6).

8. Metal Panel Flashings (Sill Flashings)

8.1.1 Material thickness and dimension requirements shall complywith Table 2 herein. Alternatively, counter-flashing manufacturers may obtain Product Approval.

8.1.2 All metal wall panels shall be closed with a foamed, or other type of compressible, closure strip approved for use with the panel profile in the roof assembly Product Approval.

8.1.3 Sill flashing may be one- or two-piece flashing forming a panel termination or forming a counter-flashing for a roof system assembly base flashing. Flashing shall be fastened with minimum approved annular ring shank roofing nails at a spacing not to exceed 12 in. o.c.

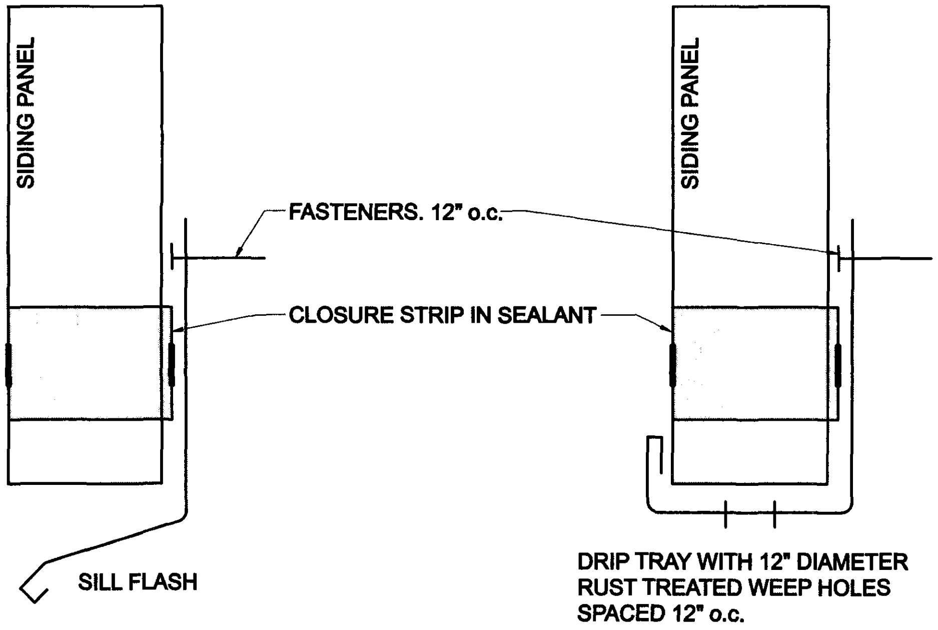


FIGURE 7
TYPICAL SILL FLASHING CONFIGURATIONS

8.1.4 Weep trays shall have $^{1}/_{2}$ in. min. diameter weep holes at a spacing not to exceed 12 in. o.c. The weep holes shall be treated to prevent corrosion.

8.1.5 Metal wall panels may be terminated with similar flashing to those noted herein.

8.1.6 Typical sill flashing configurations are noted in Figure 7, below.

9. Membrane Base Flashing

9.1 Minimum flashing shall consist of a base layer of ASTM D 226, Type II; ASTM D 4601, Type II; ASTM D 2626 base ply; or ASTM D 4897, bonded to a primed vertical surface with type IV asphalt or an approved cold adhesive or flashing cement. The base ply shall be covered with one interply of a like material to the base ply, bonded in Type IV asphalt or an approved cold adhesive or flashing cement. The top flashing ply shall be a coated or granule surfaced membrane of a material compatible with the base ply, bonded in Type IV asphalt or an approved cold adhesive or flashing cement. The top flashing ply shall have either a granular surface or be coated with an approved aluminized or emulsion coating to meet the fire classification and to resist ultraviolet exposure.

9.2 Membrane base flashings shall be mechanically attached with a continuous metal termination bar at 6 in. o.c to the vertical wall. Such termination bar shall be placed no more than $1^{1}/_{2}$ in. down from the upper edge of the membrane flashing. Membrane flashing shall terminate under a metal counter flashing or be finished with a metal surface mounted reglet attached to the wall at a spacing not to exceed 8 in. on center. The reglet shall be weatherproofed with a caulk bead of a suitable type to bond to both the metal reglet and the wall surface.

9.2.1 Anchors shall provide a minimum characteristic resistance force of 150 lbf, tested in compliance with TAS 105 or an average withdrawal resistance of 150 lbf resulting from laboratory testing after a 2:1 margin of safety is applied, and shall be installed through slotted or oversized holes.

9.3 Membrane base flashings shall not be less than 8 in. above the finished roof surface. Where existing job conditions do not al-

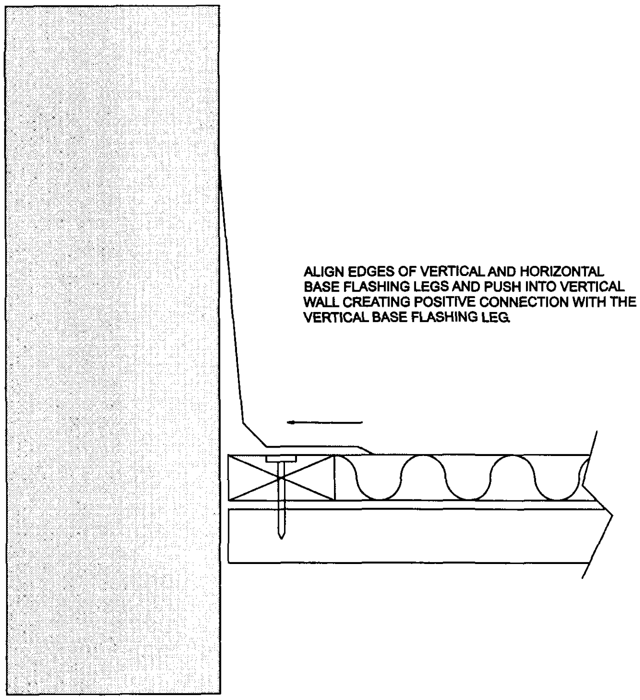

ALIGN EDGES OF VERTICAL AND HORIZONTAL BASE FLASHING LEGS AND PUSH INTO VERTICAL WALL CREATING POSITIVE CONNECTION WITH THE VERTICAL BASE FLASHING LEG.

FIGURE 8
METAL BASE FLASHING CONNECTION WITH VERTICAL WALL

low membrane base flashing to be 8 in. above finished roof surface, the counter flashing may terminate 4 in. above the finished roof surface.

9.4 Membrane base flashings shall be continuous across the transition between the wall and roof.

9.5 All vertical junctions shall be provided with a cant strip. Base flashing shall extend a minimum of 8 in. above finished roofing. Membranes shall not be angled up or down greater than 45 degrees where exposed as part of the waterproofing layer unless specifically detailed in roof assemblies published literature. Published detailed drawings shall be submitted with the Uniform Building Permit Application to the building official for review.

9.6 In nonasphaltic single-ply roofing installation, metal base flashings or perimeter drip edge/gravel stop may be sealed with proprietary bonding methods, such as coated metal for thermoplastic welding or contact adhesives to bond membrane to prepared metal or other surfaces, in accordance with roof assemblies manufacturer's published literature. Metal terminations shall be secured in compliance with the provisions herein and in compliance with Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

9.7 Bituminous roofing systems may be terminated by multiply felts, modified bitumen flashing, or in accordance with roof assemblies manufacturers published literature. When asphaltic systems are bonded to metal, all metal shall be fully primed with ASTM D 41 primer. Metal terminations shall be secured in compliance with the provisions herein and in compliance with Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

10. Termination Bars

10.1 Termination bars may be fabricated in a variety of shapes and profiles and should be fabricated from materials having a high stiffness coefficient to evenly distribute the loads incurred on fasteners. Termination bars shall be a minimum thickness of 1/8 in.

10.1.1 Holes in the termination bar shall be slotted or oversized to allow for dimensional changes in the metal.

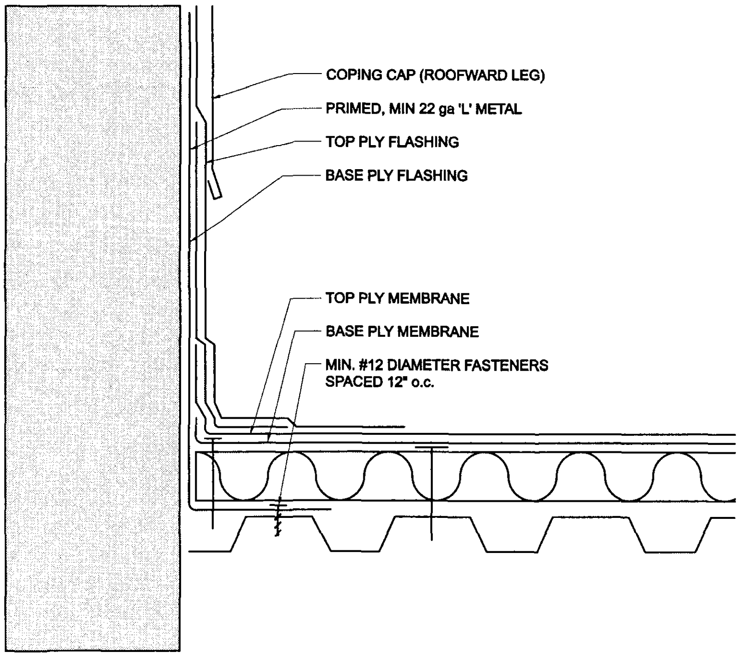

COPING CAP (ROOFWARD LEG)
PRIMED, MIN 22 ga 'L' METAL
TOP PLY FLASHING
BASE PLY FLASHING
TOP PLY MEMBRANE
BASE PLY MEMBRANE
MIN. #12 DIAMETER FASTENERS SPACED 12" o.c.

FIGURE 9
EXAMPLE OF ADHERED MEMBRANE ROOF SYSTEM ASSEMBLY TERMINATION

10.1.2 All termination bars shall be tested for corrosion resistance in compliance with Appendix E of TAS 114. (DIN 50018).

10.2 Minimum attachment requirements for termination bars shall include the following.

- All termination bar fasteners or anchors shall have a minimum $^1/_4$ in. diameter. Anchors shall provide a mini mum characteristic resistance force of 180 lbf, tested in compliance with TAS 105 or an average withdrawal resistance of 180 lbf resulting from laboratory testing after a 2:1 margin of safety is applied, and shall be installed through slotted or oversized holes at a spacing not greater than 8 in. o.c. except as required in Section 9.2. At the discretion of the building official a field withdrawal resistance test in compliance with TAS 105 may be required to confirm performance.

- All termination bar fasteners or anchors shall be fabricated from similar or compatible material to that of the termination bar.

- A nonferrous metal bonded sealing washer shall be installed under the head of each fastener or anchor if the fastener head is left exposed. Fasteners used in the installation of termination bars to be covered by counter flashing shall not require bonded sealing washers.

- A continuous bead of approval sealant shall be applied under or at the top edge of the termination bars, which are not covered by counter flashing.

- Nylon or plastic anchors shall not be acceptable.

11. Metal base flashing

11.1 Metal base flashings shall be fabricated at an angle slightly greater than 90 degrees to create an adequate connection between the vertical leg and the adjoining vertical wall (see Figure 8).

11.2 Adhered single-ply or modified bitumen roof system assemblies not requiring a cant may be terminated at a primed, minimum 22 ga "L" metal secured to the deck (see Figure 9).

11.3 Metal base flashings for metal roofing systems shall comply with requirements of RAS 133 and those listed herein.

12. Gutters

12.1 Gutters, down spouts, and hold down components shall be secured to resist the load of gravity when full with rainwater in addition to the design wind loads of Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

12.2 Gutters, and down spouts, shall be sized in compliance with Chapter 11 of the *Florida Building Code, Plumbing.*

12.3 Gutters, down spouts, and hold down components shall be constructed in accordance with the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA) *Architectural Sheet Metal Manual,* 5th edition. In addition to the following requirements:

12.3.1 Gutter joints shall be lapped 4 in. sealed with two rows of approved sealant, and riveted with two rows of closed end rivets offset 1 in. o.c.

12.3.2 Maximum gutter lengths shall not exceed 50-ft. Gutter ends shall not be butted tight to a wall or other obstruction, which may prevent thermal expansion of metal.

ROOFING APPLICATION STANDARD (RAS) No. 113
STANDARD REQUIREMENTS FOR JOB SITE MIXING OF ROOF TILE MORTAR

1. Scope

1.1 The standards set forth herein provide an alternate means of adhering roof tile by mixing the mortar at the job site, for jobs where the mean roof height does not exceed 24 ft.

1.2 When using job site mortar mix, approval by the building official and compliance with this RAS are required for every roof tile installation.

1.3 All testing shall be conducted by an approved testing agency, certified to perform testing under this standard. A Professional Engineer, or Registered Architect, shall sign all calculations.

2. Requirements for Approval of Job Site Mix Program

2.1 Job site mortar mix for adhering roof tile shall be reviewed and approved by the building official prior to commencing the roofing job.

2.2 The mix proportions for job site mortar mix shall consist of 2 $^1/_2$ parts of ASTM C 144 sand and 1 part of ASTM C 91, Type 'M' masonry cement.

2.3 Perform a compressive strength test on three samples of above mixture, in compliance with ASTM C 109, with an average result of not less than 2,500 psi.

2.4 As part of the documentation to be submitted to the building official for approval of this adhering method, the permit applicant shall include an affidavit signed by the property owner acknowledging that he/she is the owner of the property and the he/she has accepted and understood the use of job site mortar mix on his/her job.

2.5 Perform a static uplift test in the following manner:

2.5.1 Build a testing deck to reflect conditions of existing deck system or perform test on existing roof;

2.5.2 Prepare testing deck by installing:

2.5.2.1 Anchor sheet and underlayment to reflect actual installation of proposed system; and

2.5.2.2 Five sets (three tiles per set) of proposed approved tiles with the mortar mix prepared depicting actual mixtures (tile installation shall reflect actual installation procedures);

2.5.2.3 Mortar shall be applied using a 10-in. trowel;

2.5.2.4 Position mortar mix (a fully loaded 10-in. trowel) under tile per manufacturer recommendations;

2.5.2.5 Condition completed testing deck by totally exposing it to similar environment conditions as the job site, for a period of not less than 14 days;

2.5.3 Preparation of testing deck and mixture of mortar mix shall be performed by the same workers that will do the actual installation of proposed system.

2.5.4 Laboratory shall witness the deck and mortar mix preparation and shall monitor conditioning of same.

2.5.5 Perform uplift test (following same procedures set in TAS 101), results of this test shall be equal to or greater than those required of actual job site condition times 1.45 (safety factor).

3. Job Site Mortar Mix Application

3.1 After successfully performing above test, actual job may begin.

3.2 Obtain all mandatory inspections.

3.3 Within 30 days of completing the job, perform an uplift test per TAS 106 applying a load equal to or greater than loads determined and tested under Section 2.5.5 (which includes the 1.45 safety factor) of this standard. Test twice the amount of tiles required to be tested under TAS 106.

ROOFING APPLICATION STANDARD (RAS) No. 115
STANDARD PROCEDURES FOR ASPHALTIC SHINGLE INSTALLATION

1. Scope

1.1 This roofing application standard has been developed to provide a responsive method of complying with the requirements of Chapters 15 and 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* while providing a prescriptive method of installing asphaltic shingles.

2. Definitions

2.1 For definitions of terms used in this application standard, refer to ASTM D 1079 and the *Florida Building Code, Building*.

3. General

3.1 Asphaltic shingles shall not be installed on roof mean heights greater than 33 feet, unless specifically specified in the roof assembly's Product Approval. Roof slope criteria shall be in accordance with Table 1515.2.

3.2 Where asphaltic shingles are to be installed over insulated roof deck, a suitable nailable substrate, in accordance with Section 1520.5.7 must be installed over the insulation prior to the installation of approved underlayment and shingles.

3.3 Asphaltic shingles shall be installed in compliance with the Product Approval installation specifications, but in no case with less than six approved roofing nails (12 ga. by $1^1/_4$ in. corrosion-resistant annular ring shank roofing nails) or approved fastening devices which penetrate through the sheathing or wood plank a minimum of $^3/_{16}$ in. or penetrate a 1 in. or greater thickness of lumber a minimum of 1 in. except where architectural appearance is to be preserved, in which case a minimum of $^3/_4$ in. nail may be used.

4. Underlayment

4.1 Minimum prescriptive underlayments shall be one of the following, unless otherwise specifically noted in roofing assembly Product Approval:

- A double layer of an ASTM D 226, Type I,with a 19-inch headlap; or
- A single layer of an ASTM D 226, type II with a 4-inch headlap; or
- A single layer of an ASTM D 2626 coated base sheet with a 4-inch headlap.
- All endlaps shall be a minimum of 6 inches.
- All valleys shall be woven.

4.2 All underlayments shall be fastened with approved minimum 12 gage by 11/4 in. corrosion-resistant annular ring shank roofing nails fastened through minimum 32 gage by 15/8 in. diameter approved tin caps. Maximum fastener spacing shall be 6 in. o.c. at the laps with two additional rows in the field at a maximum spacing of 12 in. o.c. Nails shall be of sufficient length to penetrate through the sheathing or wood plank a minimum of $^3/_{16}$ in. or penetrate 1 inch (25 mm) or greater thickness of lumber a minimum of 1 in., except where architectural appearance is to be preserved, in which case a minimum of $^3/_4$ in. nail may be used.

4.3 If the underlayment is a self-adhering membrane, the membrane shall be applied over a mechanically attached anchor/base sheet attached in compliance with this section above.

5. Metal Accessories

5.1 All metal accessories shall be in compliance with Section 1517.6 of the *Florida Building Code, Building* and RAS 111.

5.2 Eave and gable drip metal vertical face shall be a minimum of $1^1/_2$ inches and shall extend down not less than $^1/_2$ inch below the sheathing or other member immediately contiguous thereto. In all cases, the deck flange shall be not less than 2 inches in width. Where required, a continuous clip (hook strip) shall be installed in compliance with RAS 111.

5.3 Eave and gable drip metal shall be joined by a lapped of a minimum of 4 in. and the entire interior of the joints shall be coated with approved flashing cement. Eave and gable drip metal shall be fastened with minimum 12 gauge annular ring shank nails at a maximum spacing of 4 in. o.c. The nails shall be manufactured from similar and compatible material to the termination profile. All composite materials shall be fastened with nonferrous nails. All metal profiles shall be installed in compliance with RAS 111.

5.4 Valley metal shall be a minimum 16 in. wide rolled or preformed material of thickness' in compliance with Section 1517.6 of the *Florida Building Code, Building*. Valley metal shall be set over the underlayment, or over an optional 18 in. sweat sheet. Fasten valley metal with minimum 12 gage by $1^1/_4$ in. annular ring shank roofing nails of similar materials 12 in. o.c. 1 in. in from each exterior edge. The entire edge of the flange shall be sealed, covering all nail penetrations with flashing cement and membrane. All horizontal laps shall be a minimum of 6 in. and shall be fully embedded with approved flashing cement. No nails shall be permitted in the center of the valley.

6. Shingle Installation

6.1 At all intersections, eaves, rakes, valleys, and gable ends the shingles and starter strips shall be set in a minimum 8-in. wide strip of approved flashing cement. Maximum thickness of flashing cement shall be $^1/_8$ in. as excessive use of the cement may cause blistering, or bleed through. Shingles shall not extend more than $^1/_4$ in. beyond the eave drip.

6.2 The starter strip may be either a row of nonlaminated shingles trimmed to the shingle manufacturer's recommendations or a strip of mineral-surfaced roll roofing not less than 7 in.wide.

6.3 If self-sealing shingles are used for the starter strip, remove the tab portion of each shingle and position the remaining strip with the factory-applied adhesive face up along the eaves. Trim material from the end of the first shingle in the starter strip according to manufacturer's specifications to ensure that the cutouts of the first course of shingles are not placed over the starter strip joints. Fasten starter strips parallel to the eaves along a line above the eave line according to manufacturer's specifications. Position fasteners to insure they will not be exposed under the cutouts in the first course.

6.4 For shingles without a self-sealing strip the tabs shall be removed and approved flashing cement shall be applied in spots approximately the size of a quarter at the corner of each tab of the first course. Starter shingles shall be nailed along a line not greater than 4 in. above the eave line nailing not greater than 6 in. o.c. Ensure that the cutouts of the first course are not placed over the starter strip joints.

6.5 If roll roofing is used for the starter strip, nail along a line not greater than 4 inches above the eave line nailing not greater than 12 inches o.c. Approved flashing cement shall be applied as noted above for nonsealing shingle starter. If more than one piece of roll roofing must be used, the end joint shall be butted. Joints shall be staggered with succeeding shingle joints, and the number of starter joints shall be kept to a minimum.

6.6 First course shall be laid straight, checking it regularly during application against a horizontal chalk line. A few vertical chalk lines aligned with the ends of shingles in the first course will ensure proper alignment of cutouts. A shingle hatchet is an acceptable alternative to the use of succeeding chalk lines. The first course starts with a full shingle, while succeeding courses shall be installed in strict compliance with the shingle manufacturers' Product Approval course layout detail.

6.7 Valley courses shall be terminated with shingles not less than 12 in. in length. Rake courses shall terminate with shingles not less than 6 in. length. To obtain the correct exposure for square-tab strip shingles, align the butts with the top of the cutouts in the course below. Install no-cutout shingles and those with variable butt lines according to the manufacturer's directions to obtain correct exposure.

NOTE: Follow manufacturer's instructions concerning shingle alignment. See "Exposure, Course Layout, and Fastening Detail" in shingle manufacturer's Product Approval.

7. Fastening

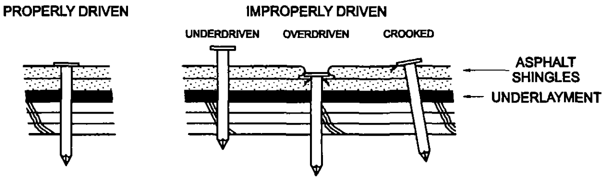
7.1 Use six approved nails per shingle. Place the fasteners in strict compliance with shingle manufacturers Product Approval course layout, fastening details.

7.2 Align the shingles properly to avoid exposing fasteners in the course below. Drive the fasteners straight and do not break the shingle surface with the fastener head. Do not drive fasteners into knot holes or cracks in the roof deck. Repair faulty fastening immediately. If fastener is improperly driven or exposed, remove the fastener and repair the hole in the shingle with approved flashing cement or replace the entire shingle.

7.3 Do not nail into or above factory-applied adhesives. Ensure no cutout or end joint is less than 2 inches from a nail in an underlying course. Start nailing from the end nearest the shingle just laid and proceed across. Do not attempt to realign a shingle by shifting the free end after two nails are in place. Drive nails straight so that the edge of the nail head does not cut into the shingle. Nail heads should be driven flush with the shingle surface. Fasteners shall not be improperly driven (see Detail A).

8. Valleys

8.1 Valleys may be applied in open, closed or woven fashion. Valley metal shall be in compliance with Section 5.4.



DETAIL A

8.2 Open valley: Snap two chalk lines, one on each side of the valley centerline over the full length of the valley flashing. Locate the upper ends of the chalk lines 6 in. apart in the center of valley at the ridge (i.e., three inches to either side of the valley centerline). The lower ends should diverge from each other a *minimum* of $^{1}/_{8}$ in. per linear foot of valley length, (i. e., for an eight foot long valley the chalk lines shall be 7 inches apart at the eaves).

As shingles are applied toward the valley, trim the last shingle in each course to fit on the chalk line. Never use a shingle trimmed to less than 12 inches in length to finish a course running into a valley. If necessary, trim a tab off the adjacent shingle in the same course to allow a longer portion to be used, trim 1 inch on a 45-degree angle from the upper corner to direct water into the valley and prevent it from penetrating between the courses. Finally, to form a tight seal, cement the shingle to the valley lining with a minimum eight-inch width of asphalt flashing cement. There should be no exposed nails along the valley flashing.

8.3 Closed cut valley: With valley flashings already in place, apply the first course of shingles along the eaves of one of the intersecting roof planes and across the valley. For proper flow of water over the trimmed shingle, always start applying the shingles on the roof plane that has the lower slope or lesser height. Extend the end shingle at least twelve inches onto the adjoining roof. Do not make a joint in the valley. If a shingle falls short, add in one or two tab sections so that joint occurs outside the line of the valley. Apply succeeding courses in the same manner, extending them across the valley and onto the adjoining roof. Press shingle tightly into the valley. Use normal shingle fastening methods except that no nails should be within six inches of the valley centerline and two nails shall be placed at the end of each shingle crossing the valley. Snap a chalk line two inches from the centerline of the valley on the under-shingled side. Then apply shingles on the under shingled side. Trim the shingles as they are being installed to the chalk lines to ensure a neat installation. Trim one inch on a 45-degree angle from the upper corner of each shingle upon installation. This will direct water into the valley. Finally embed each end shingle in a 3-inch (76 mm) wide strip of flashing cement.

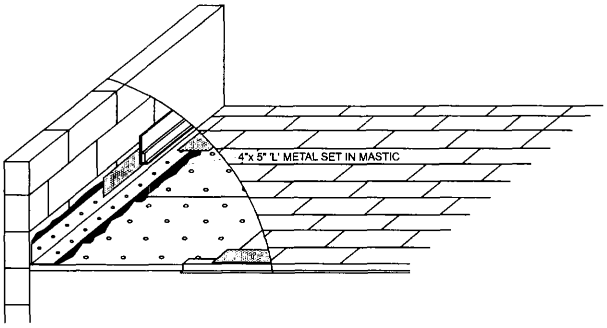
8.4 Woven valley: The valley flashing should already be in place as described earlier. Shingles on the intersecting roof surfaces may be applied toward the valley from both roof areas simultaneously or each roof area may be worked separately up to a point about three feet from the center of the valley and the gap closed later. Regardless of which procedure is followed, apply the first course along the eaves of one roof area up to and over the valley with the last shingle extending at least 12 inches onto the intersecting roof. Then apply the first course of the intersecting roof along the eaves and extend it across the valley over the top of the shingle already crossing the valley and at least 12 inches onto the other surface. Apply successive courses alternately from the adjoining areas, weaving the valley shingle over the other. Press each shingle tightly into the valley. Use normal shingle fastening methods except that no nails should be within six inches of the valley centerline and two nails shall be placed at the end of each shingle crossing the valley.

9. Flashing

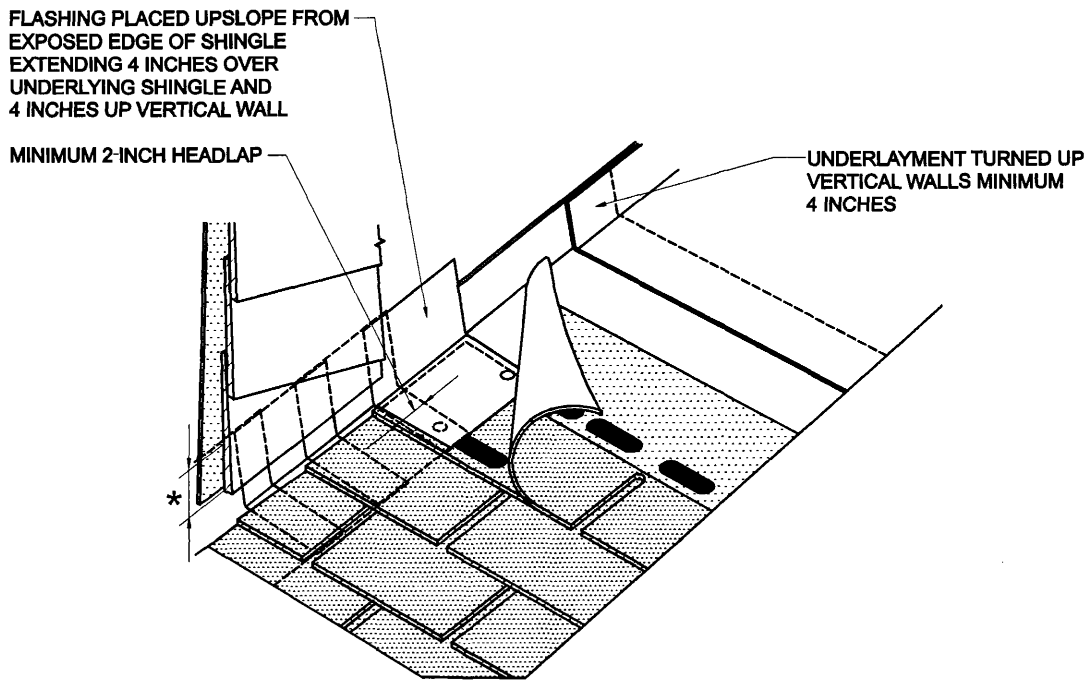
9.1 All shingles that butt against wall flashings shall be step bulled with approved flashing cement a minimum of eight inches, and all roof planes that butt against vertical walls shall be flashed in one of the following manners:

9.2 Option A: All wall abutments shall be flashed with a minimum of 4 in. by 5 in. "L" metal flashings of materials and thickness in accordance with Section 1517.6 of the *Florida Building Code, Building*. The metal "L" flashing shall be set in approved flashing cement and set flush to base of wall and over underlayment (see Detail B). Both horizontal and vertical metal flanges shall be fastened 6 inches o.c. with approved fasteners. Fastening shall be in accordance with RAS 111. All laps shall be a minimum of 4 inches fully sealed in approved flashing cement. Flashing shall start at the lower portion of the roof to ensure water-shedding capabilities of all metal laps. The entire edge of the metal flashing shall be sealed covering all nail penetrations with approved flashing cement and membrane. The metal "L" flashing shall be counter flashed. All metal counter flashing shall be installed in accordance with RAS 111.

9.3 Option B: Roof planes that butt against vertical walls shall be step flashed with 10 in. long metal shingles which are 2 in. wider than the exposed face of the roofing shingles (see Detail C). Place the first flashing unit over the end of the starter strip and position it so that the tab of the end shingle in the first course covers it completely. Secure the horizontal arm to the roof with two approved roofing nails. Do not nail flashing to the wall; settling of the roof could damage the seal. Apply the



DETAIL B


FLASHING PLACED UPSLOPE FROM EXPOSED EDGE OF SHINGLE EXTENDING 4 INCHES OVER UNDERLYING SHINGLE AND 4 INCHES UP VERTICAL WALL
MINIMUM 2-INCH HEADLAP
UNDERLAYMENT TURNED UP VERTICAL WALLS MINIMUM 4 INCHES
*

DETAIL C

first course of shingles up to the wall. Position the second step flashing strip over the end shingle in the first course 5 inches up from the butt so that the tab of the end shingle in the second course covers it completely. Fasten the horizontal arm to the roof. The second course of shingles follows, the end is flashed as in the preceding courses and so on to the top of the intersection. Bring siding or other wall treatment down over the vertical sections of the step flashing to serve as cap flashing. Wall treatment or cap flashing shall terminate a minimum of 1 in. above the roofline. All metal counter flashing shall be installed in accordance with RAS 111.

9.4 Head/apron flashing at all vertical end walls: Apply shingles up the roof until a course must be trimmed to fit at the base of the vertical wall. Adjust the exposure slightly in the previous two courses so that the last course is at least 8 inches wide. Apply a continuous piece of metal flashing over the last course of shingles by embedding it in approved flashing cement and nailing it to the roof. The metal flashing strip shall be bent to extend at least 5 inches up the vertical wall and at least 4 inches onto the last shingle course. Do not nail the strip to the wall. Apply an additional row of shingles over the metal flashing strip, trimmed to the width of the strip. Bring siding down over the vertical flashing to serve as cap flashing. Wall treatment or cap flashing shall terminate a minimum of 1 in. above the roofline. Do not nail siding into the vertical flashing. If the vertical front wall meets a side wall, as in dormer construction cut flashing so that it extends at least 7 inches around the corner. Continue up the side wall with step flashing as detailed above.

10. Soil Stacks and Vent Pipes

10.1 Apply shingles up to the vent pipe. Cut a hole in a shingle to go over the pipe and set the shingle in ASTM D 4586 flashing cement. A preformed flashing flange that fits snugly over the pipe is then placed over the shingle and vent pipe and set in approved flashing cement. Place the flange over the pipe to lay flat on the shingle below. After the flashing is in place, resume shingle application. Cut shingles in successive courses to fit around the pipe and embed them in approved flashing cement where they overlap the flange. Avoid excessive use of cement as it may cause blistering. Do not drive fasteners close to the pipe. The lower part of the flange shall overlap the lower shingles and the side and upper shingles shall overlap the flange.

10.2 For ventilator and exhaust stacks, follow the same procedure, but bring the shingles up to the pipe from both sides and bend the flange over the ridge to lie in both roof planes, overlapping the roof shingles at all points. Ridge shingles are then positioned to cover the flange. Embed the ridge shingles in approved flashing cement where they overlap the flange. Roof ventilators shall be flashed in accordance with ventilators Product Approval.

11. Chimneys

11.1 Chimneys shall be flashed with a two-piece base and cap flashing to allow for differential movement. Apply shingles up to the front edge of the chimney before any flashings are installed. Apply a coat of ASTM D 41 asphalt primer if the chimney is constructed of masonry or metal to seal the surface and to provide good adhesion to all points where flashing cement will later be applied.

11.2 Install flashing in accordance with Section 9 above. Apply the base flashing to the low side of the chimney first. Bend the base flashing so that the lower section extends at a minimum of 4 inches over the shingles and the upper section extends a minimum of 12 inches up the vertical face of the chimney. Work the flashing firmly and smoothly into the joint between the shingles and chimney. Set both the roof and chimney overlaps in approved flashing cement placed over the shingles and on the chimney face. The flashing shall be secured in accordance with RAS 111. Use metal step flashing for the sides of the chimney, positioning the units in the same manner as flashing on a vertical side wall, in accordance with Details A and B herein. Secure each flashing unit to the masonry with approved flashing cement and to the deck with approved nails. Embed the end shingles in each course that overlap the flashing in an 8" bed of approved flashing cement. Place the rear base flashing over the cricket and the high side of the chimney. Chimney crickets shall be waterproofed in compliance with the shingle manufacturers published literature. All chimney flashings shall be countered flashed. Metal counter flashing shall be in accordance with RAS 111.

12. Hips and Ridges

12.1 Apply premanufactured hip and ridge shingle components or cut hip and ridge shingles from manufacturer's strip shingles. Lay hip and ridge away from prevailing wind. Insure all fasteners are covered. Exposure shall not exceed 5 inches. Taper the lap portion of each cap shingle slightly so that it is narrower than the exposed portion.

ROOFING APPLICATION STANDARD (RAS) No. 117
STANDARD REQUIREMENTS FOR BONDING OR MECHANICAL ATTACHMENT OF INSULATION PANELS AND MECHANICAL ATTACHMENT OF ANCHOR AND/OR BASE SHEETS TO SUBSTRATES

1. Scope

1.1 The standards set forth herein provide a means of determining proper attachment of anchor and/or base sheets and insulation panels.

1.2 All testing shall be conducted by an approved testing agency. A Professional Engineer, or Registered Architect, shall sign and seal all calculations.

2. Anchor and Base Sheets, General

2.1 All damaged stress plates shall be removed and replaced.

2.2 Insulation shall only be attached with approved insulation fasteners.

3. Insulation, General

3.1 All insulation fasteners shall be installed in compliance with the fastener manufacturer's published installation instructions and the limitations set forth in the Product Approval. Insulation attachment for panels in the field area of the roof shall use a fastener spacing in compliance with Figures 1 through 4 of this Application Standard, as referenced in the Roof Assembly Product Approval. Fastener placement guidelines shall be as follows:

- Fasteners installed at insulation panel edges shall be spaced not greater than 13$^1/_2$ inches nor less than 4 $^1/_2$ inches from the edge of the panel.

- Fasteners shall be evenly distributed over the panel area.

3.2 All insulation fasteners and stress plates shall be tested in compliance with Chapter 15 (High-Velocity Hurricane Zone) of the *Florida Building Code, Building*. Minimum withdrawal resistance for insulation fasteners shall be 275 lbf.

3.3 For recover or reroof applications over an existing steel deck, having a thickness less than 22 gage, insulation fasteners shall be tested for withdrawal resistance in compliance with TAS 105.

3.4 Insulation fasteners and stress plates, and minimum acceptable insulation panel size and thickness shall be as listed in the roof assembly Product Approval.

3.5 Installation of more than one insulation layer using a single fastener shall utilize the fastening pattern and fastener designated for the top insulation panel.

3.6 Mixing of insulation panels (e.g., different manufacturer's, insulation types) shall not be acceptable when applied in the same layer.

3.7 Only as much insulation as can be roofed shall be installed each working day. Water shall not be allowed to run in the flutes of steel deck ribs under completed roof sections.

3.8 Insulation panels shall be installed with minimum joint dimensions and shall be tightly butted. Maximum joint widths shall be $^3/_8$ in.

3.9 All insulation joints shall be staggered. Tapered insulation shall be installed in accordance with manufacturer's recommendations.

3.10 Tapered insulation may be substituted for any flat stock type listed in the Roof System Assembly Product Approval. The fastening requirements shall remain the same. Polyisocyanurate tapered insulation systems shall have a minimum average thickness per panel of 1 in.

3.11 Insulation pieces that are cut from larger panels and are smaller than one square foot shall not be acceptable.

3.12 All insulated decks containing interior drains shall be sumped at the drains. Sump area insulation shall be tapered at a minimum slope of $^{1}/_{8}$ of an inch per foot to the drain. The drain sump area shall be a minimum of (24 in. by 24 in.) 576 square inches, unless restricted by a wall or any other obstruction.

3.13 All overdriven fasteners or fasteners driven at an angle, shall be removed and replaced. If the insulation facer has been broken by a stress plate, that section of insulation panel shall be removed and replaced.

3.14 Attachment of any low density insulation panel, fiberglass or mineral wool, shall be with self-locking fasteners.

3.15 Insulation fasteners and stress plates shall be installed with tooling specified by the fastener manufacturer.

3.16 Predrilling, if any, shall be with the diameter bit listed in the withdrawal resistance test report. The drill bit tolerance range noted in the test report shall be maintained throughout the project. Should a change in bit size be required due to varying density of the deck material, an additional withdrawal resistance test shall be conducted to confirm fastener performance. Drill holes shall not spalled.

3.17 When installing "hammer-in" concrete fasteners, all deformed stress plates shall be removed and replaced.

3.18 Concrete dust shall be removed by brushing or forced air from the insulation top surface prior to the application of hot asphalt or adhesive.

3.19 Roof insulation and roll goods, either on the ground or on the roof top, shall be kept dry. The building official shall instruct the removal of the insulation or roll goods from the job when elevated moisture levels are found.

4. Insulation Attachment Over Steel Decks

4.1 Steel deck insulation fasteners shall penetrate the top flange of a steel deck not less than ½ in.

4.2 The two opposite edges of any insulation panel shall be supported on the top flanges of the steel deck, and shall have a minimum bearing width of 1½ in. unless restricted by top flange width. Alternatively, minimum 22 gage galvanized or painted sheet steel may be placed over the deck ribs and secured with minimum #12 diameter fasteners spaced 18 in. o.c. (see Figure 5).

4.3 Steel deck sections shall properly "nest," allowing insulation panels to have full contact with the top flanges. If any deck sections do not "nest" properly, the sections shall be repaired prior to the application of the roof insulation. Cutting, scoring or hollowing of the insulation panels is not acceptable.

5. Insulation Attachment Over Concrete Decks

5.1 Threaded concrete fasteners shall be a minimum of a #14 diameter. "Hammer-in" concrete fasteners having a length less than or equal to 8 in. shall have a minimum diameter of $^{3}/_{16}$ in. "Hammer-in" concrete fasten-

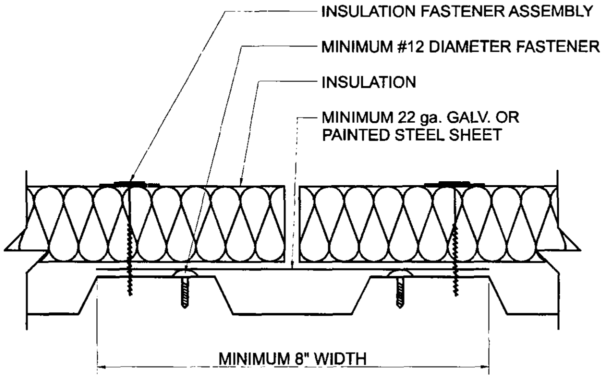

INSULATION FASTENER ASSEMBLY
MINIMUM #12 DIAMETER FASTENER
INSULATION
MINIMUM 22 ga. GALV. OR PAINTED STEEL SHEET
MINIMUM 8" WIDTH

FIGURE 5
USE OF STEEL SHEET TO ENSURE SUPPORT OF INSULATION PANEL GAGES

ers having a length in excess of 8 in. shall have a minimum diameter of $^1/_4$ in.

5.2 Insulation fasteners shall penetrate the concrete deck a minimum of $1^1/_4$ in.

6. Lightweight Insulating Concrete

6.1 New pours of lightweight insulating concrete shall be tested for fastener withdrawal in compliance with Section 1917 of the *Florida Building Code, Building*.

6.2 Rigid roof insulation panels shall not be applied directly over lightweight concrete decks.

6.3 For recover or reroof applications where the proposed mechanical attachment is through the lightweight insulating concrete and to the structural deck, a TAS 105 withdrawal resistance test of the proposed fastener shall be conducted. Calculations based on the TAS 105 shall be submitted to the building official for evaluation of the proposed fastening method.

7. Wood Decks

7.1 Approved insulation fasteners shall be used for insulation attachment to wood decks. Nails are not acceptable for insulation attachment.

8. Perimeter, and Corner Roof Areas

8.1 The roofing assembly Product Approval shall list the maximum design pressure for the accepted assembly. Such pressure shall be applicable to the field of the roof area (1) as defined in ASCE 7. Should the roof assembly Product Approval allow extrapolation to perimeter and corners areas (2 and 3) as defined in ASCE 7, the following shall apply.

- The maximum extrapolation shall not be greater than 280 percent except as noted in Section 9.2.
- The minimum fastener separation shall not be less than 4 in. o.c.
- If the perimeter and/or corner areas of the roof have calculated design pressures which are less than or equal to the maximum design pressures noted in the roof assembly Product Approval, then specified anchor/base sheet or insulation attachment shall also apply in these areas.
- If the minimum design pressure exceeds the roof assembly maximum design pressure such roofing system may be granted a one-time approval by the authority having jurisdiction, provided the applicant demonstrates, by testing and/or rational-analysis that such roofing system complies with the provision of the *Florida Building Code.*

8.1.1 In recover or reroof applications, if testing in compliance with TAS 105 of the insulation fasteners results in a minimum characteristic resistance force less than 275 lbf (1224 N), a Professional Engineer, or Registered Architect shall perform a moisture survey, in compliance with TAS 126, and examine the deck's integrity. The moisture survey and examination results, along with the withdrawal resistance test results and a proposed deck repair/replacement specification, shall be submitted to the building official for review prior to issuance of a roofing permit.

Subsequent to repair or replacement of the deck, a withdrawal resistance of the fasteners shall be conducted. The same criteria noted above shall apply.

8.2 As an alternate to data extrapolation, or in the event data extrapolation is not allowed, in-situ (on-site) field uplift resistance testing of the in place roof assembly may be conducted in elevated pressure zones to confirm uplift resistance performance. Testing shall be conducted in compliance with TAS 124. Such Field uplift resistance testing shall be conducted to 1.45 times the design pressure for the tested pressure zone, and submitted to the building official for review.

9. Insulation Attachment — New Construction/Reroof Application

9.1 Example of Data Extrapolation:

9.1.1 Given:
A building having a roof mean height less than 60 feet where the design pressures are as follows:

Field Area: *- 43.0 psf*
Perimeter Area: *- 56.0 psf*
Corner Areas: *- 90.0 psf*

Consider a Roof Assembly Product Approval, which includes a system having an accepted maximum design pressure of -45 pound per square foot (2155 Pa). The Product Approval specifies 4-ft by 4-ft insulation panels attached with four fasteners per panel.

9.1.2 Determine the required number of fasteners per insulation panel to meet the design pressures in the elevated pressure zones.

General Equation:

$$\left(\frac{known\ \#\ of\ fasteners}{max.\ design\ pressure}\right)=\left(\frac{unknown\ \#\ of\ fasteners}{elevated\ design\ pressure}\right)$$

Perimeter Area:

$$\left(\frac{4\ fasteners}{45\,psf}\right)=\left(\frac{X\ fasteners}{56\,psf}\right)\varnothing\ X=4.9\ fasteners$$

All fractions shall be rounded up to the next whole number. Therefore, the perimeter insulation panels shall be fastened with five fasteners per 4-ft by 4-ft panel. Fastener locations shall be in compliance with Figure 3, herein.

Corner Areas:

$$\left(\frac{4\ fasteners}{45\,psf}\right)=\left(\frac{X\ fasteners}{90\,psf}\right)\varnothing\ X=8\ fasteners$$

Therefore, corner panels shall be attached with eight fasteners per 4-ft by 4-ft panel. Fastener locations shall be in compliance with Figure 3, herein.

9.2 If the data extrapolation results in a number of fasteners for an elevated pressure zone which exceeds 280 percent of that for the field area, additional testing, as determined by the building official, may be required to confirm the performance of the Roof System Assembly.

9.3 If an insulation panel overlaps into an elevated pressure zone (i.e. field area insulation panel overlapping into the perimeter or corner area of the roof, or a perimeter area insulation panel overlapping into the corner area of the roof), the more stringent fastener density shall apply to the entire overlapping panel.

9.4 For multilayer insulation systems, the fastener density specified for the top panel shall be used. If the top layer is bonded in hot asphalt, the fastener density of the base insulation layer shall be used.

9.5 Alternatively, the base sheet of an approved roof assembly may be mechanically attached with insulation fasteners and plates through the insulation panels to

TABLE 1
SQUARE FEET PER FASTENER FOR COMMON ANCHOR/BASE SHEET ATTACHMENT PATTERNS

Field Area Attachment Pattern From Roof Assembly Product Approval		Square Feet per Fastener
Side Lap Row	**Center Row(s)**	
7 $^{1}/_{2}$ in. o.c.	one row, 7 $^{1}/_{2}$ in. o.c.	0.83
9 in. o.c.	two staggered rows, 12 in. o.c.	0.80
9 in. o.c.	two staggered rows, 18 in. o.c.	1.00
12 in. o.c.	two staggered rows, 12 in. o.c.	0.89
12 in. o.c.	two staggered rows, 18 in. o.c.	1.14
12 in. o.c.	two staggered rows, 24 in. o.c.	1.33

the structural deck to increase the uplift performance of the roof assembly. Base sheet fastener spacing shall be as listed in roof assembly Product Approval, or may be determined in compliance with Section 10, herein.

9.6 For buildings of mean roof height greater than 60 feet the example above shall also apply.

10. Anchor or Base Sheet Attachment – New Construction/Reroof Applications

10.1 This section covers determination of anchor/base sheet fastener applications. Anchor/base sheet attachment for elevated pressure zones may be determined through extrapolation of the data for field area attachment. Data extrapolation outlined in Section 10.4.4 utilizes field area attachment data currently found in roof assembly Product Approval.

- For steel deck applications, fastener spacing shall be in increments of 6 in. o.c.

10.2 The following calculations have been performed for several common anchor/base sheet attachment patterns, the results of which are noted in Table 1 of this Roofing Application Standard. The values listed in Table 1 apply solely to anchor/base sheets having a width less than or equal to 36 inches and applications having a side lap equal to or greater than 4 in.

10.3 If the field area attachment pattern from the roof assembly Product Approval is not listed in Table 1, or the anchor/base sheet has a width in excess of 36 inches, or the side lap is less than 4 in. wide, then the following calculations shall be conducted to determine the number of square feet per fastener.

10. Example of Data Extrapolation:

10.4.1 Given:

A building having a concrete deck and a roof mean height less than 60 feet where the design pressures are as follows:

Field Area: *- 43.0 psf*
Perimeter Area: *- 56.0 psf*
Corner Areas: *- 90.0 psf*

Consider a roof assembly Product Approval, which includes a system having a maximum design pressure of -45 psf (2155 Pa). The Product Approval specifies an anchor/base sheet, having a width of 36 in. attached with approved fasteners and bearing plates at a spacing of 12 in. o.c. at a 4 in. side lap and two rows staggered in the center of the sheet, 24 in. o.c.

10.4.2 Determine the number of square feet per fastener.

To determine the number of square feet per fastener, first determine the length of anchor/base sheet, which will yield one net square (i.e., 100 ft.^{2})

Net Width of Sheet (ft):

$$Net\ Width\ (ft) = \frac{(Sheet\ Width) - (Side\ Lap\ Width)}{12}$$

$$Net\ Width(ft) = \frac{(36\ in) - (4\ in)}{12} = 2.67\ feet$$

Net Length to Make One Square (100 ft^2):

$$Net\ Length = \frac{(100\ ft^2)}{Net\ Width}$$

$$Net\ Length = \frac{(100\ ft^2)}{(2.67\ ft)} = 37.5\ ft$$

Determine the total number of fasteners per square.

General Equation:

$$\left(\frac{1\ fastener}{A}\right) \times \left(\frac{12\ in.}{ft.}\right) \times \left(\frac{B}{row}\right) \times \left(\frac{C}{square}\right) = D$$

where:
A = specified fastener spacing (inches);
B = net length (in feet) to make one square;
C = number of rows having spacing (A); and,
D = number of fasteners per square.

Side Lap Row:

$$\left(\frac{1\,fastener}{12\,in}\right)\times\left(\frac{12\,in}{ft}\right)\times\left(\frac{37.5\,ft}{row}\right)\times\left(\frac{1\,row}{square}\right)=37.5\ \frac{fasteners}{square}$$

Center Rows:

$$\left(\frac{1\,fastener}{24\,in}\right)\times\left(\frac{12\,in}{ft}\right)\times\left(\frac{37.5\,ft}{row}\right)\times\left(\frac{2\,rows}{square}\right)=37.5\ \frac{fasteners}{square}$$

Combining these values leads to a total of 75 fasteners per square, which equates to 1.33 square feet per fastener, as noted below.

$$\frac{\left(\frac{100\ \text{ft}^2}{square}\right)}{\left(\frac{\text{37.5 side lap fasteners}}{\text{square}}\right)+\left(\frac{\text{37.5 center row(s) fasteners}}{\text{square}}\right)}=\text{1.33 per fastener}$$

10.4.3 Determine the "fastener value:"

General Equation:

f_y = (max. design pressure) x (ft^2 per fastener)

$$f_y=\left(\frac{45\,lbf}{ft^2}\right)\times\left(\frac{1.33\,ft^2}{fastener}\right)=60.0\,lbf$$

10.4.4 Determine anchor/base sheet fastener spacing (FS) to meet the design pressures in the elevated pressure zones of the roof.

10.4.5 ***General Equation:***

$$FS=\frac{f_y\times 144}{P\times RS}$$

FS = fastener spacing (in.);
f_y = fastener value (lbf):
P = design pressure (psf): and
RS = row spacing (in.).;

NOTE: As noted in the above equation, the row spacing is not needed to determine the fastener spacing. The row spacing is merely the net width of the sheet divided by the number of rows. For this case, the net width is 32 in. and there are three fastener rows (i.e. one side lap row and two center rows). This leads to a row spacing of 10.7 in.

Perimeter Area:

$$FS=\frac{(60.0\,lbf)\times\left(\frac{144\ in.^2}{ft.^2}\right)}{(56.0\,psf)\times(10.7\,inches)}=14.4\ inches$$

All fractions shall be rounded down to the next whole number. Therefore, perimeter area anchor/base sheet attachment could be with three rows spaced 10.7 in. apart, 14 in. o.c. Generally, side lap fastener spacing should not exceed 12 in. o.c.

Corner Area:

$$FS=\frac{(60.0\,lbf)\times\left(\frac{144\ in.^2}{ft.^2}\right)}{(90.0\,psf)\times(10.7\,inches)}=9.0\ inches$$

Therefore, a fastener spacing of 9 in. o.c. at a 4 in. side lap and two rows staggered in the center of the sheet, 9 in. o.c. would be an acceptable corner area anchor sheet fastener spacing.

10.5 In recover applications anchor/base sheet attachment applications shall utilize approved insulation fasteners and bearing plates. Anchor or base sheet fasteners or nails shall not be utilized in such applications.

10.6 For buildings of mean roof height greater than 60 feet the example above shall also apply.

11. Architectural Appearance Applications

11.1 Design Values

11.1.1 The design value for architectural appearance applications shall be the

TABLE 2 TYPICAL FASTENER VALUES FOR ARCHITECTURAL APPEARANCE APPLICATIONS			
Wood Deck Fastener	**Substrate**	**Min. Penetration**	**Fastener Value**
12 gage annular ring shank nail	Nominal 1 in. Wood Plank (i.e., $^{13}/_{16}$ in. tongue and groove)	$^{3}/_{4}$ in	32.00
#7 wood screw	Nominal 1 in. Wood Plank (i.e., $^{13}/_{16}$ in. tongue and groove)	$^{3}/_{4}$ in	45.00
#7 wood screw	Nominal $^{19}/_{32}$ in. Plywood	$^{7}/_{16}$ in	37.50

TABLE 3 TYPICAL 'DYNAMIC PULL THROUGH VALUES' FOR ARCHITECTURAL APPEARANCE APPLICATIONS		
Anchor or Base Sheet	**Bearing Plate Diameter**	**Dynamic Pull-Through Value (lbf)**
ASTM D 226, Type II (30# Organic Felt) with hot mopped mineral surfaced roll roofing	$1^{5}/_{8}$ in	38.20
ASTM D 4601, (Fiberglass) with hot mopped mineral surfaced roll roofing	$1^{5}/_{8}$ in	49.40

lesser of either the "Fastener Value" of the fastener, determined in compliance with TAS 105 or the "dynamic pull-through value" of the anchor/base sheet over the proposed bearing plate, determined in compliance with TAS 117(B). Values shall be listed in fastener/plate manufacturer's Product Approval.

11.1.2 Tables 2 and 3, below, list typical "Fastener Values" and "Dynamic Pull-through Values," which may be used to determine anchor/base sheet fastener spacing in compliance with this section. Any wood deck fasteners, anchor/base sheets, which are proposed for use in an architectural appearance application and are not listed in Tables 2 and 3 shall be tested in compliance with TAS 117(A) and/or TAS 117(B) to determine necessary design values.

11.1.3 If a proposed fastener is "larger" than those noted in Table 2, the "Fastener Value" noted in Table 2 may be utilized. If a proposed bearing plate is larger than those noted in Table 3, the "Dynamic Pull-through Value" of the anchor/base over the smallest bearing plate may be utilized.

11.2 Example of Data Extrapolation:

11.2.1 Given:

A building having a roof mean height less than 60 feet where the design pressures are as follows:

Field Area: *- 43.0 psf*
Perimeter Area: *- 56.0 psf*
Corner Areas: *- 90.0 psf*

Consider an architectural appearance application in which an ASTM D 226, Type II base sheet, having a width of 36 in., is to be mechanically attached with a 3-in. side lap, to nominal 1-in. wood plank ($^{13}/_{16}$-in. tongue and groove) using #8 wood screws and $1^{5}/_{8}$-inch diameter tin caps. One ply of approved mineral surfaced roll roofing is to be applied over the mechanically attached base sheet in a full mopping of hot asphalt.

11.2.2 Determine the design value to be used in data extrapolation.

From Table 2, the "Fastener Value" for this application is 45.0 lbf. From Table 3, the "Dynamic Pull-through Value" for this application is 38.2 lbf. Taking the lesser of the two values, the design value for this case would be 38.2 lbf.

11.2.3 Determine a base sheet fastener spacing (FS) to meet the design pressures in each pressure zone of the roof.

General Equation:

$$FS = \frac{(\text{design value}) \times 144}{P \times RS}$$

Note: The side lap, for this case is specified at 3 in. Therefore, the row spacing (RS) in the above noted equation shall be 11 inch [i.e., sheet width (36 inch) minus side lap width (3 inch) divided by the number of fastener rows (3)].

Field Area:

$$FS = \frac{(38.2\ \text{lbf}) \times \left(\frac{144\ in^2}{ft^2}\right)}{(40.0\ \text{psf}) \times (11\ \text{inches})} = 12.5\ \text{inches}$$

All fractions shall be rounded down to the next whole number. Therefore, a fastener spacing of 12 in. o.c. at a 3-in. side lap and two rows staggered in the center of the sheet, 12 in. o.c. would be an acceptable field area base sheet fastener spacing.

Perimeter Area:

$$FS = \frac{(38.2\ lbf) \times \left(\frac{144\ in^2}{ft^2}\right)}{(47.0\ psf) \times (11\ inches)} = 10.7\ inches$$

All fractions shall be rounded down to the next whole number. Therefore, a fastener spacing of 10 in. o.c. at a 3-in. side lap and two rows staggered in the center of the sheet, 10 in. o.c. would be an acceptable perimeter area base sheet fastener spacing.

Corner Areas:

$$FS = \frac{(38.2\ lbf) \times \left(\frac{144\ in^2}{ft^2}\right)}{(55.0\ psf) \times (11\ inches)} = 9.1\ inches$$

All fractions shall be rounded down to the next whole number. Therefore, a fastener spacing of 9 in. o.c. at a 3-in. side lap and two rows staggered in the center of the sheet, 9 in. o.c. would be an acceptable perimeter area base sheet fastener spacing.

12. Bitumen or Adhesive Application, General

12.1 Insulation panel sizes listed in the Product Approval are the minimum approved sizes and thickness. Panels up to 4 ft. by 4 ft. may be installed in hot asphalt or approved cold adhesive, as specified in roof assembly Product Approval.

12.2 Not less than 85 percent of each insulation panel shall be in contact with the substrate and bonded with asphalt or adhesive, unless a specific intermittent adhesive attachment pattern is detailed in the roof assembly manufacturer's Product Approval.

12.3 Insulation panels set in hot asphalt shall be "walked in" to ensure complete adhesion to the substrate. Multiple "walk-in" procedures may be required for foam adhesive products that expand during the curing process.

12.4 For recover applications where the insulation panels are to be bonded to an existing roof membrane, all loose gravel shall be completely removed and the substrate shall be fully primed with ASTM D 41 primer. For applications where the insulation panels are to be bonded to a structural concrete deck, the deck shall be fully primed with ASTM D 41 primer. Primer shall be allowed to completely dry prior to asphalt applications.

12.5 Approved foam adhesive applications of insulation panels shall be applied in strict compliance with the foam adhesive manufacturer's Product Approval.

12.6 No extrapolation for the elevated pressure zones, as defined by ASCE 7, shall be allowed in adhered roof assemblies.

12.6.1 Bonded roof assembly may be tested in accordance with TAS 124 to verify attachment in the elevated pressure zones. The number of tests required shall comply with this Section. A minimum of four test specimens shall be conducted on each roof level with not less than two tests being conducted in each elevated pressure zone (perimeters and corners). One additional test shall be conducted for every 25 roofing squares of the elevated pressure zone area. A 1.45:1 margin of safety shall be applied to the test results.

13. Bitumen or Adhesive Application, Structural Concrete

13.1 A "Deck Dryness Test" shall be performed on structural concrete decks prior to asphalt application. The following procedures are specified for testing the dryness of the roof deck.

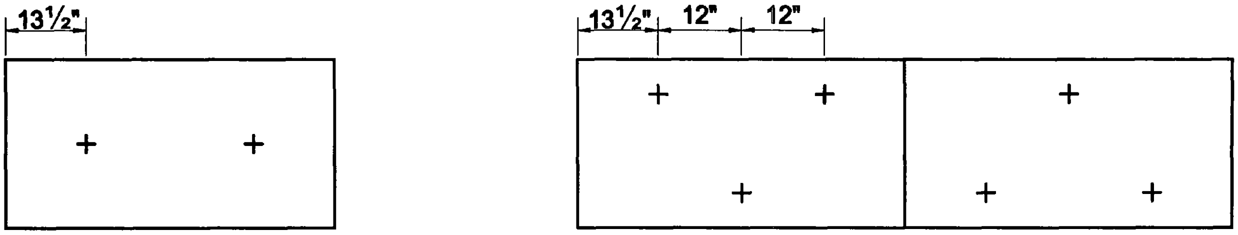
13.1.1 Heat not less than one pint of the specified asphalt to 400°F. Pour into a container.

13.1.2 Pour the asphalt on the primed deck surface. If the asphalt foams, the deck contains too much moisture for the asphalt to bond.

13.1.3 After the asphalt has cooled, pull the asphalt patch from the deck surface. If the asphalt patch strips clean, the deck is not dry enough for Roof System Assembly application. Wait a further period for the deck to dry and a sufficient asphalt bond can be achieved. Repeat the test procedure.

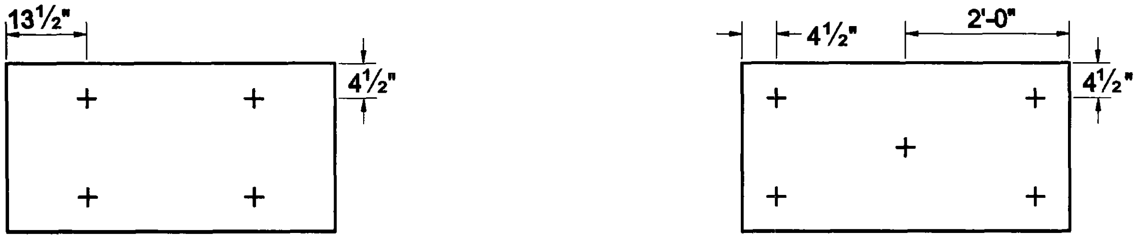
13.2 Structural concrete decks shall be primed with ASTM D 41 primer and allowed to dry prior to asphalt application, as noted in Section 12.4.

13.3 If applied directly to the deck, insulation shall be adhered in a full mopping of hot asphalt at an application rate of between 20 and 40 pounds per square, depending on the asphalt EVT. Asphalt types and temperature ranges shall be in compliance with Chapter 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*



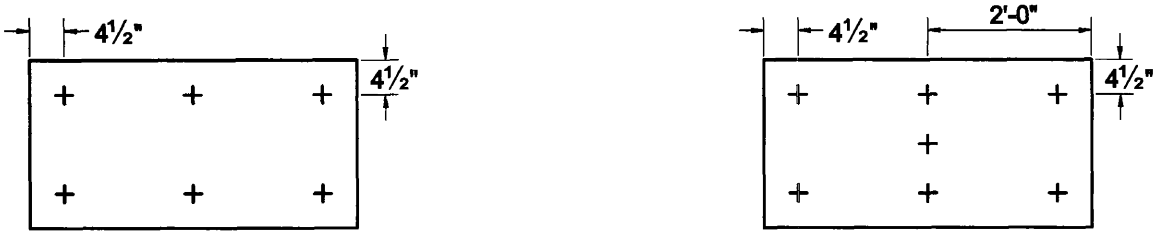
2 FASTENERS PER BOARD

3 FASTENERS PER BOARD



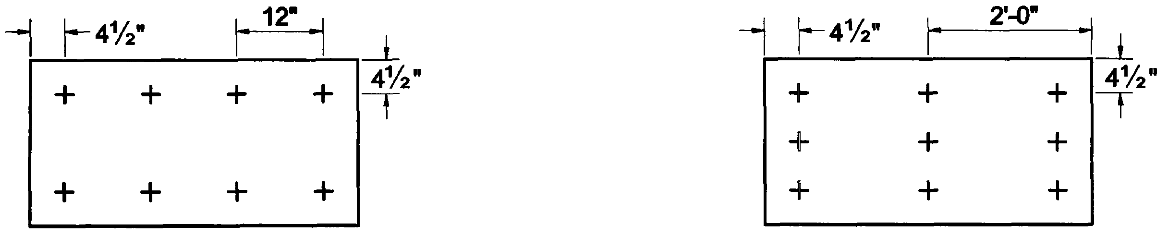
4 FASTENERS PER BOARD

5 FASTENERS PER BOARD



6 FASTENERS PER BOARD

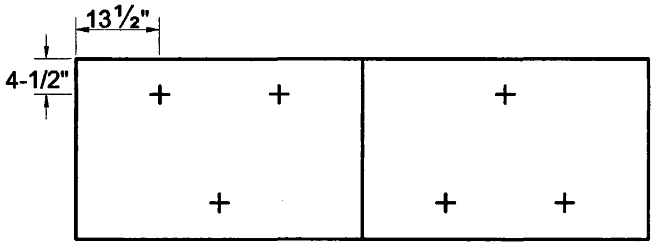
7 FASTENERS PER BOARD



8 FASTENERS PER BOARD

9 FASTENERS PER BOARD

FIGURE 1
FASTENER PLACEMENT FOR 2 FOOT BY 4 FOOT BOARDS



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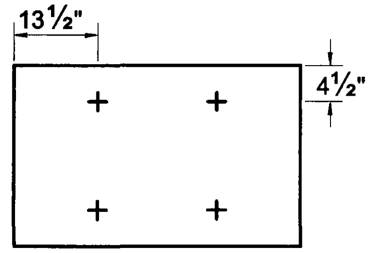

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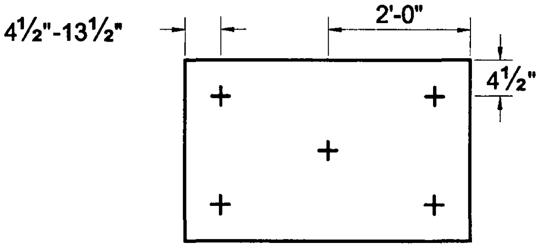

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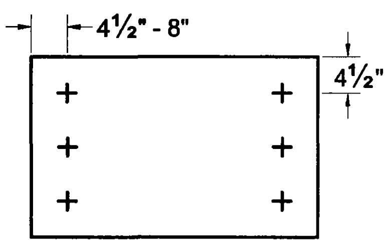

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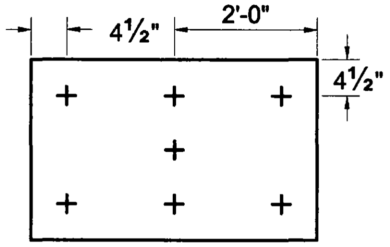

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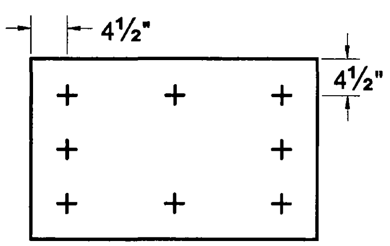

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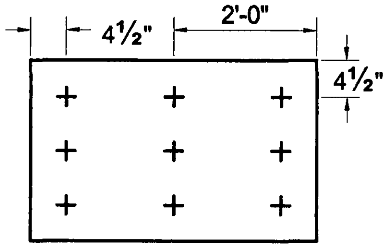

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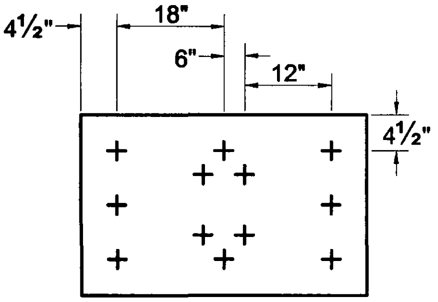

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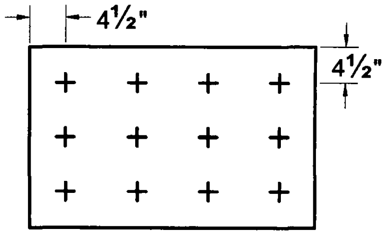
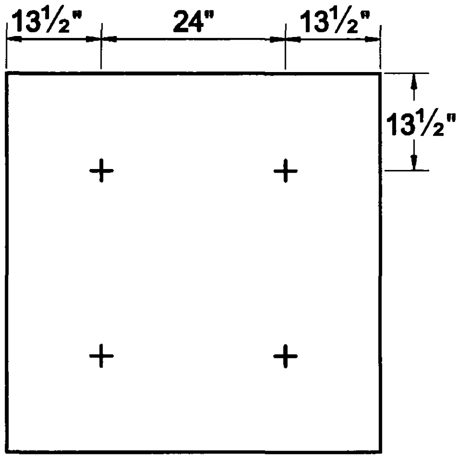


12 FASTENERS PER BOARD

FIGURE 2
FASTENER PLACEMENT FOR 4 FOOT BY 4 FOOT BOARDS



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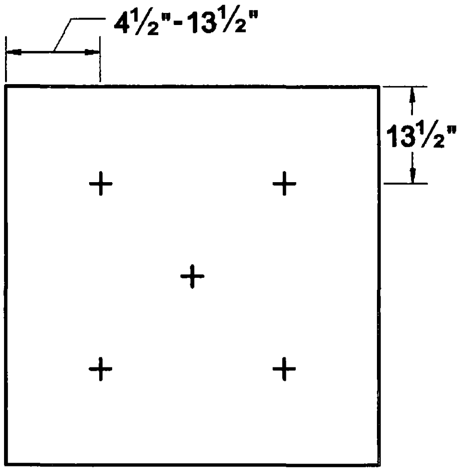

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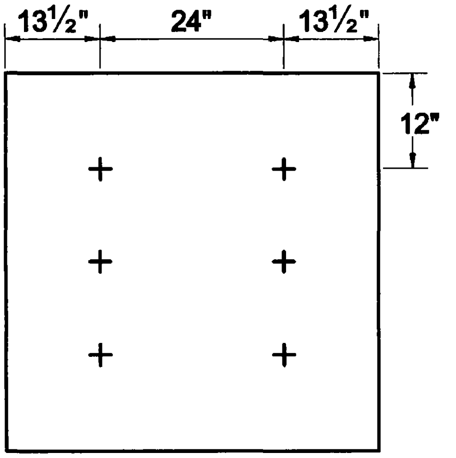

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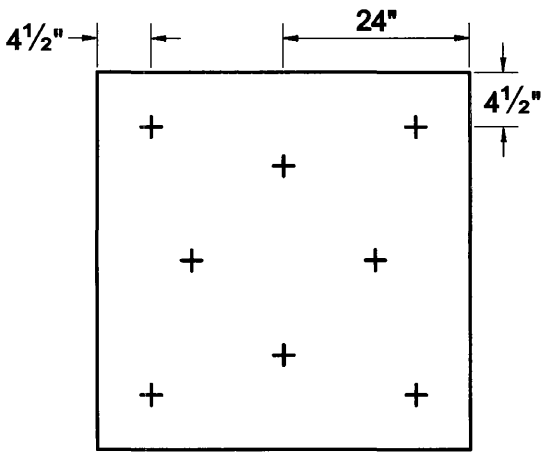
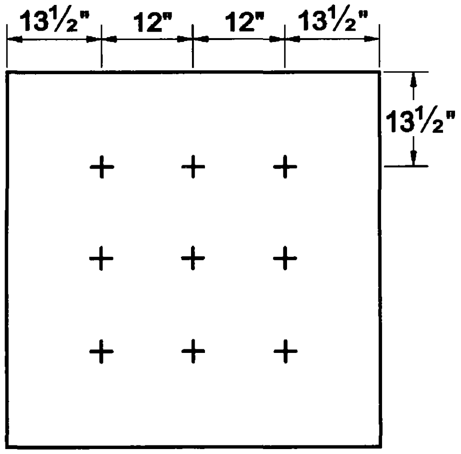
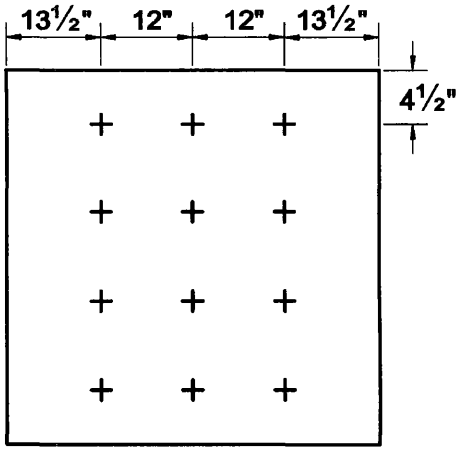


8 FASTENERS PER BOARD

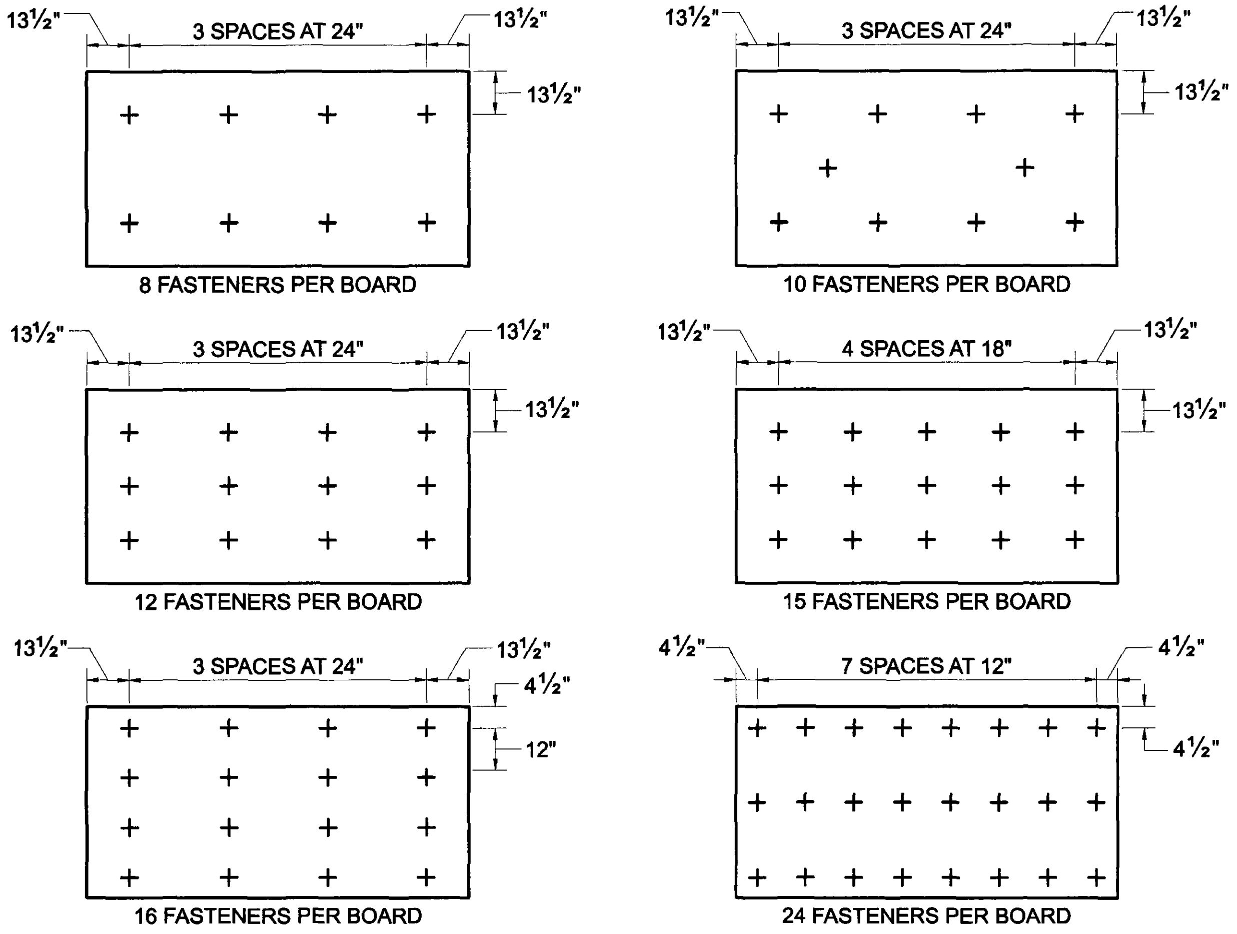


9 FASTENERS PER BOARD



12 FASTENERS PER BOARD

FIGURE 3
FASTENER PLACEMENT FOR 4 FOOT BY 4 FOOT BOARDS



8 FASTENERS PER BOARD

10 FASTENERS PER BOARD

12 FASTENERS PER BOARD

15 FASTENERS PER BOARD

16 FASTENERS PER BOARD

24 FASTENERS PER BOARD

FIGURE 4
FASTENER PLACEMENT FOR 4 FOOT BY 8 FOOT BOARDS

ROOFING APPLICATION STANDARD (RAS) No. 118
INSTALLATION OF MECHANICALLY FASTENED ROOF TILE SYSTEMS
Direct Deck & Counter Battens Only

1. Scope

This application standard covers the procedures for installation of mechanically fastened roof tile systems on direct deck or counter battens only. This standard shall be used in conjunction with the tile manufacturer's Product Approval and RAS 127.

2. Definitions

For definitions of terms used in this application standard, refer to ASTM 1079 and the *Florida Building Code, Building.*

NOTE #1: The following table provides the contractor with the choices available for underlayment systems. These systems can only be used on pitches designated in the table below:

NOTE #2: All approved tiles with integral batten-lugs, installed on counter battens may be installed on slopes up to and including 7:12. Above 7:12 horizontal battens are required unless restricted by product design (tile without batten lugs). When utilizing horizontal battens comply with RAS 119.

This roofing application standard covers Flat, Low and High profile roof tile, using a minimum 3- in. tile headlap, or design limited headlap as specified in the tile manufacturers Product Approval, on minimum $^{15}/_{32}$-in. solid decking nailed in compliance with Chapter 23 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

Roof Pitch	Counter Battens or Direct Deck	Choice of Underlayment	Plastic or Compatible Roof Cement at Nails Penetrating Underlayment	Reference
4: 12" or greater	Either	1. ASTM D 226 Type II (#30) or ASTM D 2626 (#43) organic base sheet nailed to deck, min. (#90) ASTM D 6380, Class M or WS, Type II organic cap sheet set in Type IV hot asphalt.	Required	3.01A
	Either	2. Any Product Approval Approved underlayment system with a mechanically fastened base sheet, and cap sheet set in hot, cold or self-adhered.	Per Product Approval	3.01B, C or D
	Either	3. Product Approval Listed Approved nail-on single- ply underlayment.	Per Product Approval	3.01 E

PART I - GENERAL

1.01

A. Tiles shall not be installed over wet underlayment where moisture prohibits adhesion of mastic, mortar or adhesive.

PART II - MATERIALS

2.01 Fasteners:

A. Tile Fasteners

1. All roof tile nails or fasteners, except those made of copper, monel, aluminum, or stainless steel, shall be tested for corrosion in compliance with TAS 114, Appendix E, Section 2 (ASTM G 85), for salt spray for 1,000 hours. Tile fasteners used in coastal building zones, as define in Chapter 16 (High-Velocity Hurricane Zones), shall be copper, monel, aluminum or stainless steel.

2. All roof tile fasteners shall be of sufficient length to penetrate a minimum $^1/_2$ in. through the thickness of the deck or batten, whichever is less, or to penetrate into a 1 in. or greater, thickness of lumber not less than 1 in.

3. Storm clips and storm clip fasteners – refer to Product Approval with fastener penetration as above.

B. Underlayment Fasteners:

1. Fasteners shall be in compliance with this Section 1523 of the *Florida Building Code, Building* (Herein referred to as "Approved Fasteners").

(aa) Nails shall be minimum 12 gage, annular ring shank nails having not less than 20 rings per inch; heads not less than $^3/_8$ in. in diameter; and lengths sufficient to penetrate through the plywood panel or wood plank decking not less than $^3/_{16}$ in, or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in. Nails shall be hot dipped; electro or mechanically galvanized to a thickness sufficient to resist corrosion in compliance with Appendix E of TAS 114. All nails shall be Miami-Dade listed for corrosive resistance. All nail cartons or carbon labels shall be labeled to note compliance with corrosion resistance requirements. No roof material shall be fully or partially adhered (not to include mechanically attached) directly to a nailable deck.

(bb) Such fasteners shall be applied through "tin caps" not less than $1^5/_8$ in. and not more than 2 in. in diameter and of not less than 32 gage (0.010 inch) sheet metal. All tin caps shall be Miami-Dade listed for corrosive resistance.

(cc) Prefabricated fastener systems complying with Section 1517.5, may be used, provided they are Miami-Dade listed for corrosive resistance.

2.02 Metal Flashing:

A. Flashing materials shall comply with the requirements set forth in Chapter 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*.

1. Metal accessories for roofs shall be not less than 26 gage galvanized, 28 gage stainless steel, 16-ounce copper, 0.024-inch (.61 mm) thick aluminum, lead sheet with a minimum 2.5 pound per square foot (psf) or equivalent noncorrosive lead metal alloys or composite materials manufactured for use as roof termination. All composite and nonmetallic flashing materials shall have Product Approval.

2. Metal accessories may be of a manufactured, shop fabricated or field fabricated type, provided the materials and fasteners are in compliance with the minimum requirement of this Code and shall be installed in compliance with methods set forth in RAS 111.

2.03 Asphaltic Adhesive:

A. Asphalt plastic roof cement – conforming to ASTM D 4586, Type I, nonasbestos, non-running, heavy body material composed of asphalt and other mineral ingredients.

B. Cold process modified bitumen roofing mastic – conforming to ASTM D 3019, Type III.

C. Asphalt – conforming to ASTM D 312, Type IV.

2.04 Adhesive/Sealant:

A. Structural bonding adhesive – conforming to ASTM 3498.

2.05 Mortar:

A. Materials:

1. Roof tile mortar shall either be a premixed unit having Product Approval and tested in compliance with TAS 123 or a job-site mix approved by the building official and in compliance with RAS 113.

B. Mixes:

1. Sand/cement mixes, job mixed or premixed, shall meet ASTM C 270 requirement for Type M mortar (2.25 to 2.5:1 sand to cement ratio).

2. Lightweight aggregate/cement mortar must be premixed and bagged.

2.06 Eave Closure. CHOOSE ONE of the following:

A. Prefabricated EPDM synthetic rubber conforming to ASTM D 1056.

B. Prefabricated metal eave closure must contain minimum $^3/_8$ in. diameter weepholes, spaced not more than 12 in. apart, flush with the underlayment.

C. Prefabricated concrete or clay eave closure.

D. Mortar (color optional) on granular surface underlayments only.

E. Antiponding drip edge.

2.07 Sheathing material shall conform to APA-rated sheathing, in compliance with Chapter 23 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

A. Battens – material to be decay resistant species or pressure treated in compliance with AWPA C2.

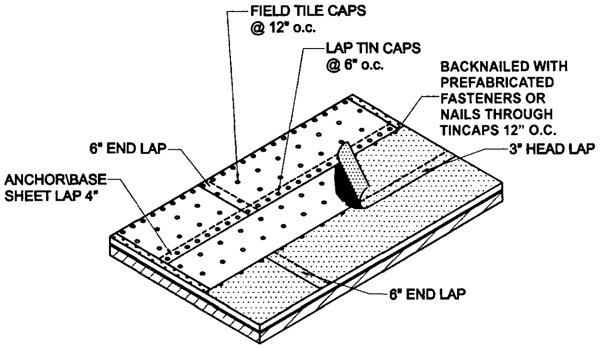
1. Battens shall not be bowed or twisted.
2. Vertical battens shall be a minimum of nominal 1 in. by 4 in., horizontal battens shall be a minimum of nominal 1 in. by 2 in.

PART III - EXECUTION

3.01 Underlayment Applications– CHOOSE ONE of the following:

NOTE #3: Anchor/base sheet shall have a minimum of two plies in the valleys. A No. 30 or No. 43 can be used as a dry in prior to installing the underlayment with this system.

A. Hot Mop 30/90, Hot Mop 43/90 (see Drawing 1). A No. 30 or No 43 anchor/base sheet ASTM D 226, Type II, or ASTM D 2626 shall be mechanically attached to the wood deck with approved fasteners spaced in a 12-in. grid staggered in two rows in the field, and 6 in. on center at the laps. Extend anchor/base sheet a minimum of 4 in. up vertical surfaces. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over installed anchor/base sheet, apply one layer of mineral surfaced cap sheet ASTM D 6380 in full 25 lb./sq, ± 15 percent mopping of asphalt. Asphalt shall be applied uniformly so that felts do not touch felts. End laps shall be a minimum of 6 in.; head laps shall be a minimum of 3 in. and backnailed 12 in. on center with approved nails through tincaps or by Miami-Dade listed for corrosion resistance prefabricated fasteners in accordance with *Florida Building Code, Building* 1517.5.1 and 1517.5.2.


FIELD TILE CAPS @ 12" o.c.
LAP TIN CAPS @ 6" o.c.
BACKNAILED WITH PREFABRICATED FASTENERS OR NAILS THROUGH TINCAPS 12" O.C.
3" HEAD LAP
6" END LAP
ANCHOR\BASE SHEET LAP 4"
6" END LAP

DRAWING 1
TYPICAL 30/90 HOT MAP

NOTE #4: The above system may be upgraded by hot mopping an interply of ASTM-listed fiberglass or perforated organic felt to the anchor sheet before applying the cap sheet. Asphalt application shall be per above specifications.

B. Hot-Applied Product Approved underlayment system (see Drawing 1). An anchor/base sheet shall be mechanically attached to the wood deck (unless directed otherwise by Product Approval) with approved fasteners spaced in a 12 in. grid staggered in two rows in the field, and 6 in. on center at the laps or as specified in the underlayment manufacturer's Product Approval. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over installed anchor/base sheet, apply one layer of cap sheet in a full 25# /sq. ± 15 percent mopping of asphalt. Asphalt shall be applied uniformly so that felts do not touch felts. End laps shall be a minimum of 6 in. on center; head laps shall be a minimum of 3 in. and backnailed 12 in. on center with approved nails through tincaps or by prefabricated fasteners in accordance with *Florida Building Code, Building* 1517.5.1 and 1517.5.2.

C. Cold-Applied Product Approved Underlayment System (see Drawing 1). An anchor/base sheet shall be mechanically attached to the wood deck with approved fasteners spaced in a 12 in. grid staggered in two rows in the field and 6 in. on center at the laps or as specified in the underlayment manufacturers Product Approval. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over anchor/base sheet, apply one layer of cap sheet in a continuous layer of cold process adhesive at the rate of 1.5 gallons per 100 sq. ft. or at the rate if so stated in the Product Approval. Adhesive shall be applied uniformly in accordance with the Product Approval with a squeegee or knotted brush. Cap sheet side laps shall be a minimum of 6 in.; head laps shall be a minimum of 3 in. and backnailed 12 in. on center with approved nails through tincaps or by prefabricated fasteners in accordance with *Florida Building Code, Building* 1517.5.1 and 1517.5.2.

D. Product Approved Anchor/Base Sheet/Self-Adhered Underlayment System. The roof cover is terminated at approved metal flashings. Any approved anchor/base sheet as listed in the Product Approval shall be mechanically attached to the wood deck with approved fasteners spaced in a 12 in. grid staggered in two rows in the field and 6 in. on center at the laps or as specified in the underlayment manufacturer's Product Approval. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over anchor/base sheet, apply one layer of any Product Approved, self-adhered underlayment in compliance with the self-adhered underlayment manufacturers' approval/ requirements.

E. Self-Adhered Underlayment (single ply). A single-ply underlayment system utilizing any Product Approved self-adhered underlayment. The roof cover is terminated at approved metal flashings. Apply one layer of any self-adhered underlayment in compliance with the underlayment manufacturer's approved/requirements.

3.02 Drip Edge Metal – CHOOSE ONE of the following:

NOTE #5: Drip edge deck flange shall be primed with ASTM D 41 asphalt primer.

A. Two-ply underlayment systems (See Drawing 2).

1. Drip-edge metal shall be installed over anchor/base sheet, fastened 4 in. on center with approved 11/4-in. roofing nails or approve fasteners. All joints shall be lapped a minimum of 4 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps.

B. When drip-edge metal shall be installed at eaves and gables over a two-ply underlayment system: The metal profile shall be placed in a minimum 3/16 in. bead of continuous ASTM D 4586 plastic roof cement and fastened 4 in. on center with approved 1$^1/_4$-in. roofing nails or approved fasteners. All joints shall be lapped a minimum of 4 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps. The metal profile and cap sheet shall be joined with a two-ply application of cotton or fiberglass fabric reinforcement, both set in a full bed of approved plastic roof cement. As an alternate, the metal may be stripped in with a 6 in. strip of torch, hot asphalt or cold adhesive polyester reinforced modified bitumen. Joints shall be feathered with cold adhesive, hot asphalt or a torch to enhance water flow across the "backlap."

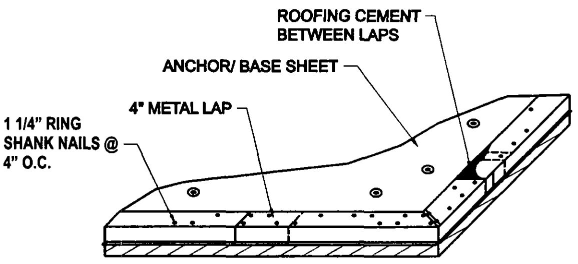
C. Single-Ply Underlayment Systems:

1. Drip-edge metal shall be installed at the eave, over the underlayment or in accordance with the underlayment manufacturer's Product Approval. The metal shall be fastened 4 in. on center with approved $1^{1}/_{4}$-in. roofing nails or approved fasteners of compatible metals. All joints shall be lapped a minimum of 4 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps.

2. Strip in metal with a minimum 6 in. strip of the single ply underlayment or in accordance with the underlayment manufacturer's Product Approval, using primer and/or approved compatible mastic if so directed by single ply manufacturer's requirements.

3.03 Valleys – CHOOSE ONE of the following:

NOTE #6 All metal surfaces to receive cap sheet shall be primed with ASTM D 41 asphalt primer.


ROOFING CEMENT BETWEEN LAPS
ANCHOR/ BASE SHEET
4" METAL LAP
1 1/4" RING SHANK NAILS @ 4" O.C.

DRAWING 2
DRIP EDGE INSTALLATION

A. Two-Ply System – CHOOSE ONE of the following (see above):

1. Preformed metal without returns or standard roll metal 16 in. wide shall be placed over the anchor/base sheet in the valley and shall be fastened 6 in. on center with 12 ga. corrosion-resistant roof nails, or other approved fasteners of compatible metals near the outside edge of the valley metal. All joints shall be lapped a minimum of 6 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps (see Drawing 3).

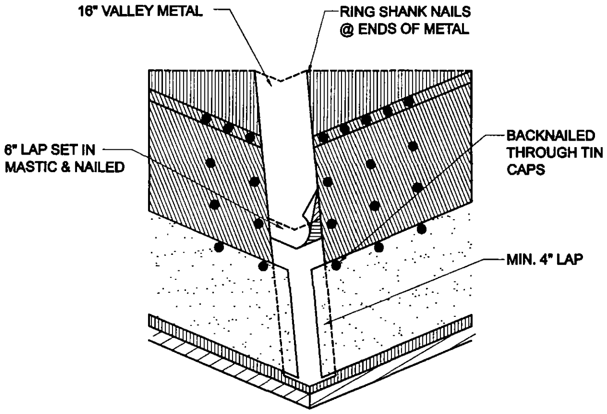
2. Preformed metal without returns or standard roll metal 16 in. wide shall be placed in the valley on top of the cap sheet and fastened 6 in. on center with 12 ga. corrosion-resistant roof nails, or other approved fasteners of compatible metals near the outside edge of the valley metal. All joints shall be lapped a minimum of 6 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps. The cap sheet shall be joined with 1/8 -in. bed of plastic

roof cement and a 4-in. strip of asphalt saturated cotton or fiberglass fabric. The fabric shall be fully embedded in the plastic roof cement. An optional #90 sweat sheet 36 in. wide may be applied prior to the installation of the valley metal and cap sheet.

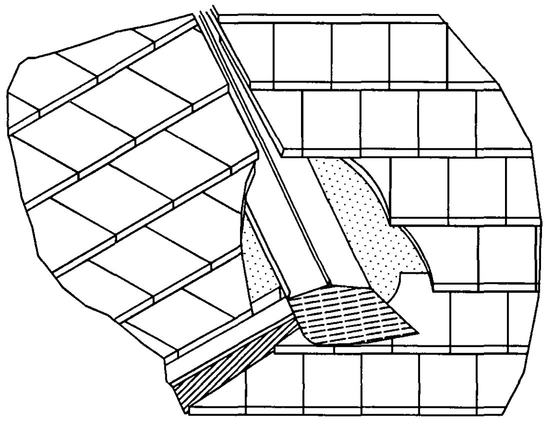
B. Single-Ply System (See Drawing 4):

1. Preformed metal without returns 16 in. wide shall be placed in the valley and shall be installed and fastened 6 in. on center with 12 ga., corrosion- resistant roof nails, or other approved fasteners of compatible metals near the outside edge of the valley metal. All joints shall be lapped a minimum of 6 in., ensuring water shedding capabilities and apply approved plastic roof cement between laps. The underlayment shall be joined with a bed of plastic roof cement and a 4-in. strip of asphalt saturated cotton or fiberglass fabric or in accordance with the underlayment manufacturer's Product Approval. The fabric shall be fully embedded in the plastic roof cement. An optional #90 sweat sheet 36 in. wide may be applied prior to the installation of the valley metal and cap sheet.
2. Standard roll metal 16 in. wide shall be placed over the anchor or cap sheet in the valley and shall be fastened 6 in. on center within 1 in. of outside edge with approved 12 ga. corrosion-resistant roof nails, or other approved fasteners of compatible metals near the outside edge of the valley metal. All joints shall be lapped a minimum of 6 in., ensuring water shedding capabilities and apply approved plastic roof cement between laps.

3.04 Flashing and Counter Flashings at Wall Abutments:


16" VALLEY METAL
RING SHANK NAILS @ ENDS OF METAL
6" LAP SET IN MASTIC & NAILED
BACKNAILED THROUGH TIN CAPS
MIN. 4" LAP

DRAWING 3
TYPICAL VALLEY INSTALLATION



DRAWING 4
VALLEY METAL STRIPPED IN

NOTE #8 In no case shall top of vertical flashing be less than 2 in. above tile surface.

NOTE #9 Flashing deck flange shall be primed with ASTM D 41 Asphalt Primer.

NOTE #10 Head/apron flashing may be installed on top of cap sheet in accordance with 3.04.A.3.

A. Two-Ply System – Choose 1 or 2 (see Drawings 5, 6, 7):

1. Install 4-in. x 5-in. "L" metal flush to base of walls with 4-in. flange on the anchor/base sheet and fasten 6 in. on center within 1 in. of outside edge. All joints shall be lapped a minimum of 4 in., ensuring water shedding capabilities and apply approved plastic roof cement between laps. Fasten vertical flange of metal within 1 in. of outside edge a minimum of 6 in. on center.

2. Install 4 in. x 5 in. "L" metal on the top ply and fastened 6 in. on center with 12 ga. corrosion resistant roof nails, or other approved fasteners of compatible metals within 1 in. of outside edge of the metal. All joints shall be lapped a minimum of 4 in., ensuring water shedding capabilities and apply approved plastic roof cement between laps. Fasten vertical flange of metal within 1 in. of outside edge a minimum of 6 in. on center. Cap sheet shall be joined with a bed of plastic roof cement and a 4 in. strip of asphalt saturated cotton or fiber glass fabric. The fabric shall be fully embedded in the plastic roofing cement.

3. Head/apron flashing may be installed on top of cap sheet. Ensure the deck flange conforms to the pitch of the roof and extend minimum 4 in. onto deck fasten according to 3.04, A. 1. Seal along edge with plastic roof cement and membrane.

4. Seal along top edge within 2 in. of the top of the vertical flange, covering all fastener penetrations with approved plastic roof cement and membrane.

5. When installing optional counter flashing, lap top flange of base flashing minimum 3 in. Fasten metal within 1" of the outside edge a minimum of 6 in. on center or set into reglets (secured properly) and thoroughly caulk. Lap joints minimum 4 in. ensuring water shedding capabilities and apply approved plastic roof cement/sealant between laps.

B. Single-Ply System.

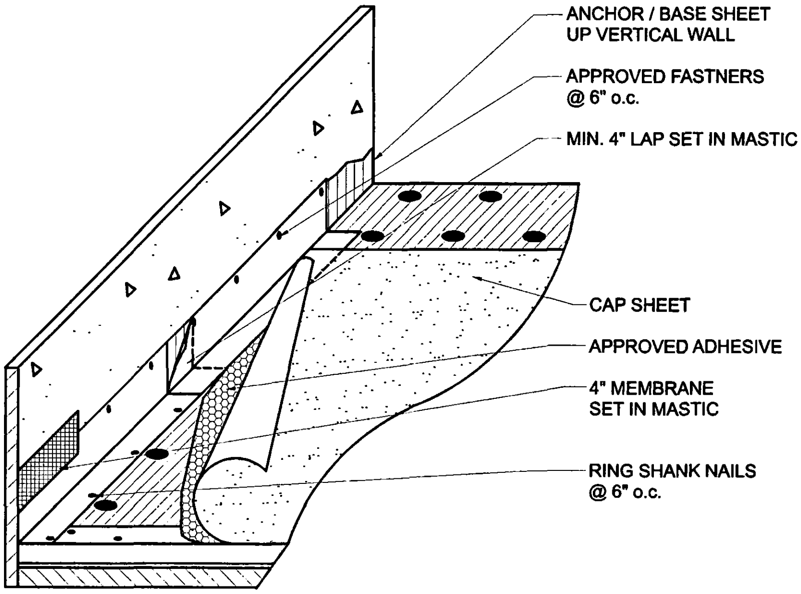
1. Install 4 in. x 5 in. "L" metal flush to base of side walls with 4 in. flange over the single ply underlayment and fasten 6 inch on center near the metals edge. All joints shall be lapped a minimum of 4 in., ensuring water shedding capabilities and apply approved plastic roof cement between laps. Mechanically fasten vertical flange of metal within 1 in. of outside edge a minimum of 6 in. on center near the edge of the metal.

2. Seal along top edge of vertical flange, covering all fastener penetrations with approved plastic roof cement and membrane.

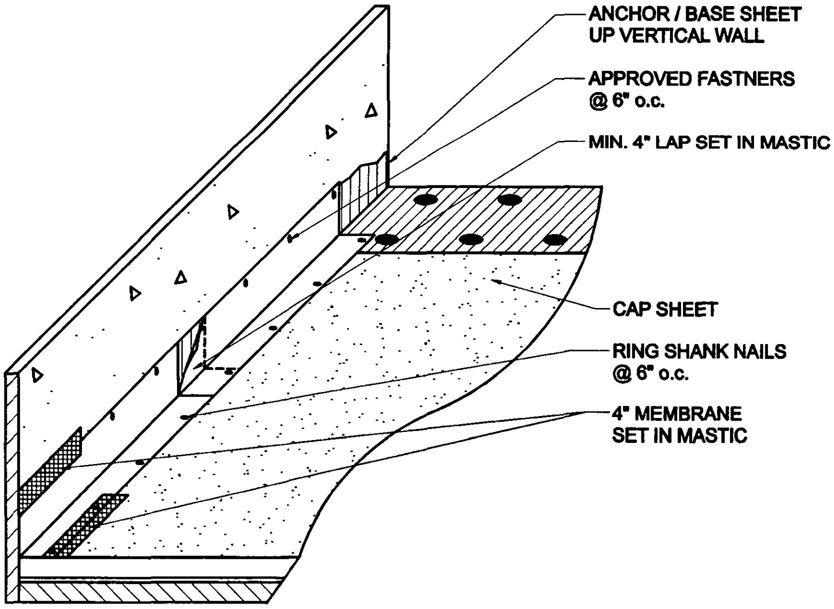
3. All head/apron flashing shall be installed on top of cap sheet. Ensure the deck flange conforms to the pitch of the roof and extend minimum 4 in. onto deck and fastened in

accordance with 3.04, B.1. Seal along edge with plastic roof cement and membrane.

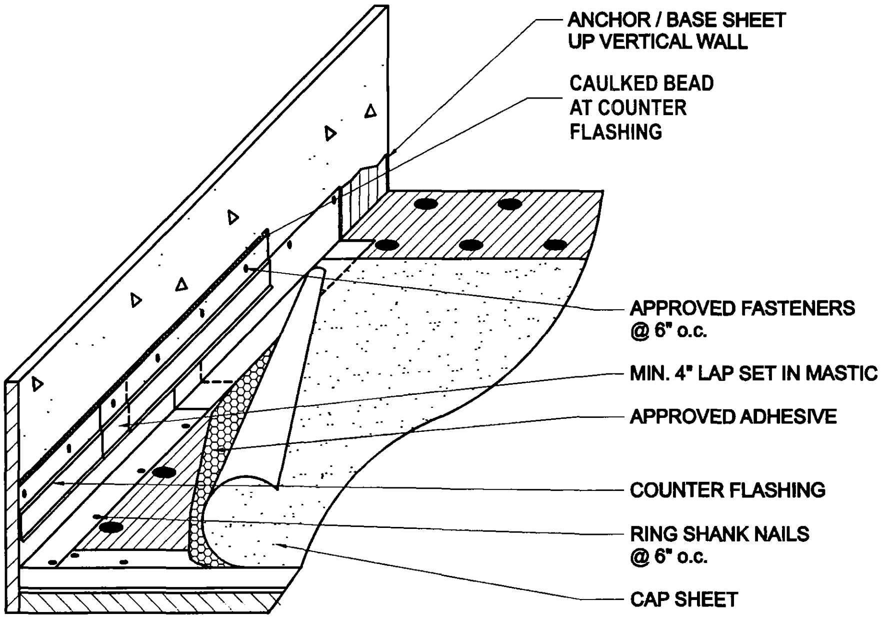
4. When installing optional counter flashing, lap top flange of base flashing a minimum of 3 in. Fasten metal within 1 in. of outside edge a minimum of 6 in. on center or set metal into reglets and seal thoroughly. Lap joints a minimum of 4 in. ensuring water shedding capabilities and apply plastic roof cement or sealant between the laps.


ANCHOR / BASE SHEET UP VERTICAL WALL
APPROVED FASTNERS @ 6" o.c.
MIN. 4" LAP SET IN MASTIC
CAP SHEET
APPROVED ADHESIVE
4" MEMBRANE SET IN MASTIC
RING SHANK NAILS @ 6" o.c.

DRAWING 5
WALL FLASHING DETAIL


ANCHOR / BASE SHEET UP VERTICAL WALL
APPROVED FASTNERS @ 6" o.c.
MIN. 4" LAP SET IN MASTIC
CAP SHEET
RING SHANK NAILS @ 6" o.c.
4" MEMBRANE SET IN MASTIC

DRAWING 6
WALL FLASHING DETAIL
(WALL FLASHING OVER CAP SHEET)


ANCHOR / BASE SHEET UP VERTICAL WALL
CAULKED BEAD AT COUNTER FLASHING
APPROVED FASTENERS @ 6" o.c.
MIN. 4" LAP SET IN MASTIC
APPROVED ADHESIVE
COUNTER FLASHING
RING SHANK NAILS @ 6" o.c.
CAP SHEET

DRAWING 7
WALL FLASHING DETAIL
(WALL FLASHING OVER CAP SHEET)

3.05 Standard Curb Mounted Skylights, Chimneys, etc.

A. Curbs shall be a minimum 2 in. x 6 in., and a minimum 2 in. above upper most adjacent finished tile surface.

B. Flashing shall follow instructions in 3.04 A or B in this System.

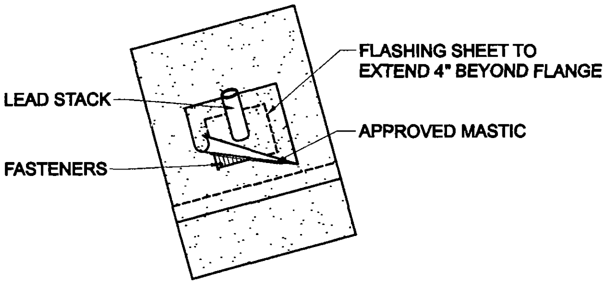
NOTE #11 For self curbing or prefabricated skylights, curb height shall be min. 6 in. and min 2 in. above upper most adjacent finished tile surface and installation shall be in accordance with skylight manufacturer's Product Approval. For turbines and other product approved accessories, refer to the accessory manufacturer's Product Approval.

3.06 Pipes, Stacks, Vents, etc. (See Drawings 8 & 9)

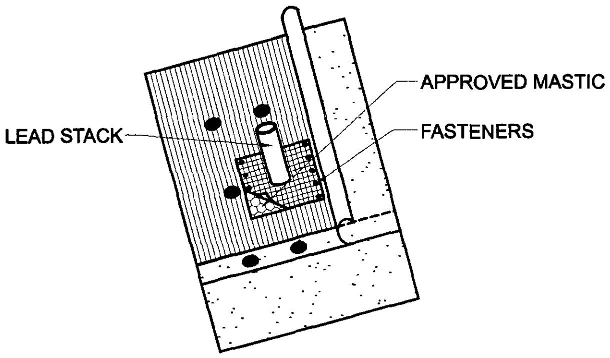
A. Apply approved plastic roof cement around base of protrusion and on the bottom side of metal flanges sealing unit base flashing to the underlayment.

B. Nail all sides within 1 in. of outside edge of base flashing 6 in. on center. Make certain base is flush to deck.

NOTE #12 If pipes, vents and/or stacks are installed after finished cap sheet has been applied follow instructions in 3.06 A & B. Cap sheet and metal flange shall be stripped in with at least the same cap sheet felt in use on this system. Stripping must extend at least 4 in. beyond flange in all directions.



DRAWING 8
LEAD STACK DETAIL
(OVER THE CAP SHEET)



DRAWING 9
LEAD STACK DETAIL
(OVER THE BASE SHEET)

3.07 Counter Batten Installation:

NOTE # 13 Seal all underlayment penetrations with plastic roof cement.

A. The tile manufacturer must possess a Product Approval for counter batten tile system installations. Counter battens are optional up to and including 7 in: 12 in. pitch. Above 7:12 horizontal battens are required unless restricted by product design (Tile without batten lugs). When utilizing horizontal battens comply with RAS 119.

B. Nominal 1 in. x 4 in. vertical battens shall be applied at spacing not greater than 24 in. on center. Secure at maximum spacing of 12 in. on center with screws of sufficient length to penetrate the deck sheathing by a minimum of $^3/_4$ in. or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in.Vertical battens shall be placed over the top cord of the roof trusses. Vertical battens may vary in length. All battens shall be installed with minimum #8 diameter corrosion resistant screw fasteners.

C. Horizontal battens shall be minimum nominal 1 in. x 4 in. or 2 in. x 2 in.

D. Fasten and secure maximum 24 in. on center through vertical battens with screws of sufficient length to penetrate the vertical batten and sheathing a minimum of $^3/_4$ in. or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in.

E. On counter batten system, install a batten parallel to the outside edge of the valley.

3.08 Tile Installation:

A. Eave Treatment - CHOOSE ONE of the following:

NOTE # 14: All fastener penetrations shall be sealed.

1. Prefabricated EPDM Synthetic Rubber - Install closure strip along eave. Fasten each piece at 12 in. on center. (See Drawing 10 all fastener penetrations shall be sealed with compatible material.)

2. Metal Eave Closure - Install closure strip along eave. Fasten a minimum 12 in. on center with approved fasteners. If metal is inclusive of drip edge, fasten 4 in. on center (see Drawing 11).

3. Raised Fascia/Wood Starter Strip - when using a $^3/_4$ in. raised fascia, a nominal 2 in. x 2 in. wood starter strip must be installed behind fascia.

(aa) Install fascia board approximately $1^1/_2$ in. above roof deck or a nominal 2 in. x 2 in. wood starter strip at roof edge (see Drawing 12).

(bb) Install 8 in. tapered cant strip at eave behind fascia and/or starter strip to support metal flashing. Install a minimum 8 in. wide anti-ponding metal flashing to ensure positive drainage over fascia/starter strip. Fasten top edge of flange onto roof and fasten eave edge to raised fascia detail with approved fastener 4 in. on center.

4. Prefabricated Concrete or Clay Eave Closure - fastened in accordance with manufacturer's Product Approval with approved fasteners.

5. Storm Clips. Storm clips shall be required at the first course of tile. The use of other alternatives including an adhesive is an acceptable means for fastening the first course of tile as long as it is part of an approved roofing system and meet the requirements of Chapter 16 of the *Florida Building Code, Building* for wind resistance.

6. Mortar Application - Install mortar to elevate eave edge.

(aa) Apply mortar along the eave edge, applying enough mortar to elevate the eave end of the tile to be on profile with the remaining roof tile.

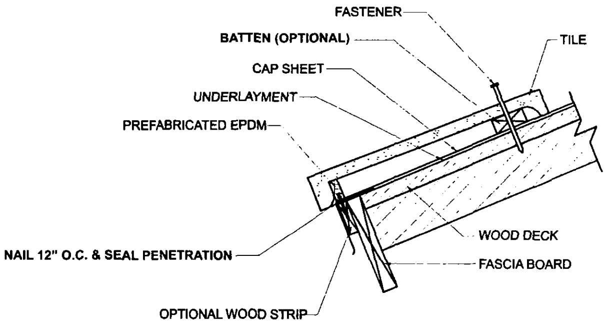
(bb) Point and smooth finish flush to eave line.

(cc) Apply minimum $^{3}/_{8}$ in. weephole flush with the roof underlayment shall be formed at the spacing of not less than one weephole per tile.

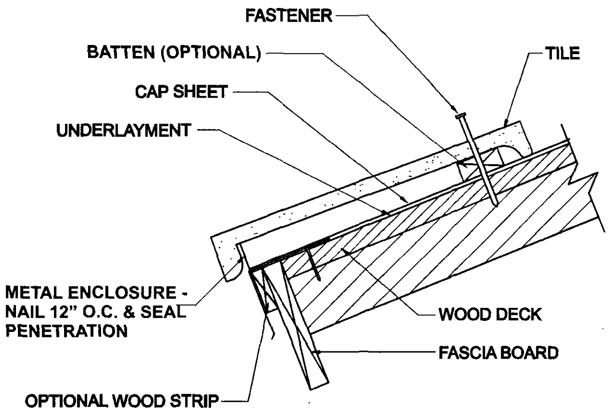
(dd) Mortar eave closures shall only be used with granular surface underlayment.

NOTE #15 All fastener penetrations shall be sealed. Mortar eave closures shall only be used with granular surface underlayments.

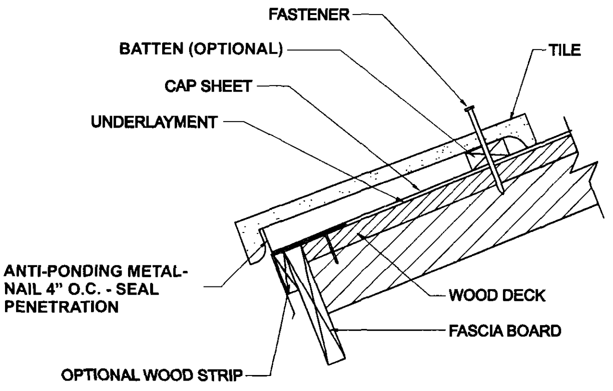
NOTE #16 Tile shall be attached to resist the design pressures for the building. See Chapter 16 of the Florida Building Code, Building (High-Velocity Hurricane Zones) and RAS 127. See tile manufacturer's Product Approval for attachment resistance values, which must exceed the required calculated design pressures of the structure.



DRAWING 10
EAVE TILE DETAIL
(NAIL-ON EPDM EAVE ENCLOSURE)



DRAWING 11
EAVE TILE DETAIL
(NAIL-ON METAL ENCLOSURE)



DRAWING 12
EAVE TILE DETAIL
(NAIL-ON ANTIPONDING METAL)

3.09 Valleys - CHOOSE ONE of the following:

A. Standard Roll Valley

1. Closed Valley - Miter tile to meet at center of valley.

2. Open Valley Chalk a line minimum 2 in. on both sides of valley center. Place bed of mortar along outside edge of chalk lines. Miter tile to form straight border and point mortar to finish.

B. Preformed Metal Without Returns

1. Closed Valley - Miter tile to form straight border on either side of water diverter.

2. Open Valley - Miter tile to form straight border on either side of two water diverters.

3.10 Hip Starter - CHOOSE ONE of the following:

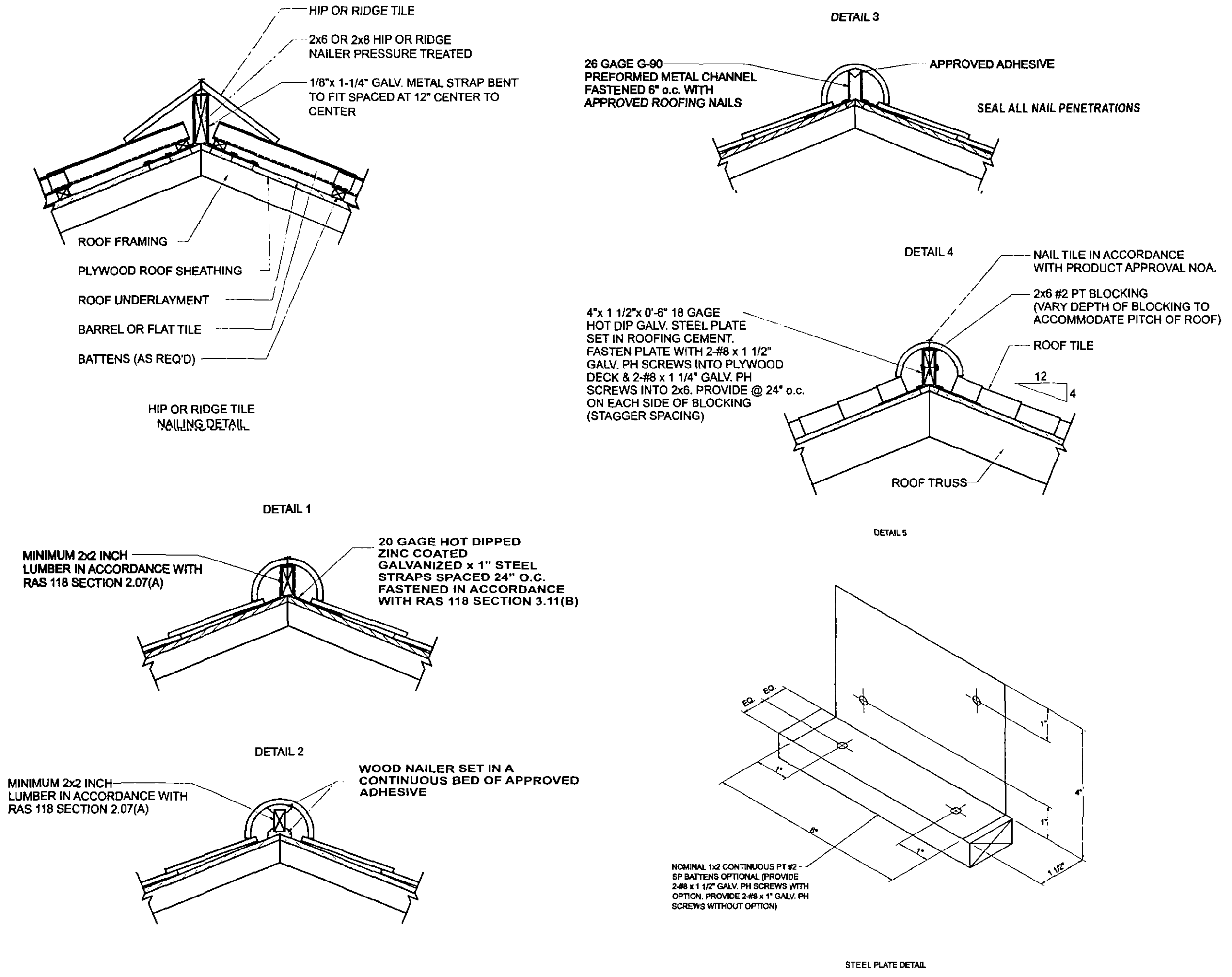
A. Prefabricated hip starter.

1. Miter tile as hip starter to match eave lines.

B. Use standard hip tiles as starter.

3.11 Hip and Ridge Nailer Boards or Preformed Metal Channel (see Drawing 13) - Details 1, 2, 3 and 4 are also accepted methods of installing Hip and Ridge Nailer Boards.

A. Wood nailers or preformed metal channel shall be required and attached in compliance with Chapter 16 (High-Velocity Hur-


HIP OR RIDGE TILE
2x6 OR 2x8 HIP OR RIDGE NAILER PRESSURE TREATED
1/8"x 1-1/4" GALV. METAL STRAP BENT TO FIT SPACED AT 12" CENTER TO CENTER
ROOF FRAMING
PLYWOOD ROOF SHEATHING
ROOF UNDERLAYMENT
BARREL OR FLAT TILE
BATTENS (AS REQ'D)
HIP OR RIDGE TILE NAILING DETAIL
DETAIL 1
MINIMUM 2x2 INCH LUMBER IN ACCORDANCE WITH RAS 118 SECTION 2.07(A)
20 GAGE HOT DIPPED ZINC COATED GALVANIZED x 1" STEEL STRAPS SPACED 24" O.C. FASTENED IN ACCORDANCE WITH RAS 118 SECTION 3.11(B)
DETAIL 2
MINIMUM 2x2 INCH LUMBER IN ACCORDANCE WITH RAS 118 SECTION 2.07(A)
WOOD NAILER SET IN A CONTINUOUS BED OF APPROVED ADHESIVE
DETAIL 3
26 GAGE G-90 PREFORMED METAL CHANNEL FASTENED 6" o.c. WITH APPROVED ROOFING NAILS
APPROVED ADHESIVE
SEAL ALL NAIL PENETRATIONS
DETAIL 4
NAIL TILE IN ACCORDANCE WITH PRODUCT APPROVAL NOA.
2x6 #2 PT BLOCKING (VARY DEPTH OF BLOCKING TO ACCOMMODATE PITCH OF ROOF)
4"x 1 1/2"x 0'-6" 18 GAGE HOT DIP GALV. STEEL PLATE SET IN ROOFING CEMENT. FASTEN PLATE WITH 2-#8 x 1 1/2" GALV. PH SCREWS INTO PLYWOOD DECK & 2-#8 x 1 1/4" GALV. PH SCREWS INTO 2x6. PROVIDE @ 24" o.c. ON EACH SIDE OF BLOCKING (STAGGER SPACING)
ROOF TILE
12
4
ROOF TRUSS
DETAIL 5
EQ.
EQ.
1"
1"
4"
1"
6"
1"
1 1/2"
NOMINAL 1x2 CONTINUOUS PT #2 SP BATTENS OPTIONAL (PROVIDE 2-#8 x 1 1/2" GALV. PH SCREWS WITH OPTION. PROVIDE 2-#8 x 1" GALV. PH SCREWS WITHOUT OPTION)
STEEL PLATE DETAIL

For SI: 1 inch = 25.4

DRAWING 13
RIDGE BLOCKING DETAIL

ricane Zones) of the *Florida Building Code, Building*.

B. Wood nailer boards shall be secured with hot dipped zinc coated galvanized steel straps of a minimum thickness of 1/8 in. by 1-1/4 in. wide. The galvanized steel straps shall be installed at a maximum spacing of 12 in. on center along the length of the ridge nailer boards. Steel straps shall be bent to fit over the ridge nailer boards, and shall be secured to the sheathing with a minimum of six #6-#8 corrosion resistant screws per strap, at a maximum spacing of 4 in. on center.

C. Preformed Metal Channel

Preformed Metal Channels shall be secured 6 in. on center with approved fasteners. All fastener penetrations shall be sealed with plastic roof cement.

D. Hip and Ridge Tile Installation - CHOOSE ONE of the following:

1. Self-adhered Membrane:

(aa) Install self-adhered membrane over nailer board and seal to tile surface per membrane manufacturer's recommendation.

(bb) Install hip and ridge tiles with corrosion resistant approved nails or screws and of sufficient length to penetrate a minimum of $^3/_4$ in. into nailer board lapping tile a minimum of 2 in. (Approved adhesive, in lieu of nails or screws, is permitted when using Details 2 and 3. When using adhesive, hip and ridge tiles shall be installed in accordance with the adhesive manufacturer's Product Approval.)

(cc) Use approved adhesive or clips at overlaps.

2. Mortar:

(aa) Set hip and ridge tile in a continuous bed of mortar, lapping tile a minimum 2 in. Ensure bed of mortar does not protrude in center of hip or ridge junction. Approximately 1 inch (25 mm) of field tile shall extend beyond bed of mortar.

(bb) Install hip and ridge tiles with approved corrosion resistant tile fastener of sufficient length to penetrate a minimum of $^3/_4$ in. into nailer board. (Approved adhesive, in lieu of nails or screws, is permitted when using Details 2 and 3. When using adhesive, hip and ridge tiles shall be installed in accordance with the adhesive manufacturer's Product Approval.)

(cc) Point mortar to finish surface.

3.12 Rake/Gable-Choose one of the following:

A. Rake/Gable Tile:

1. Install first rake tile the exposed length of first course of field tile with factory finish of rake tile towards the eave.

2. Fasten each rake tile with a minimum of two 10D nails of sufficient length to penetrate the framing a minimum of 3/4 in.

3. Abut each succeeding rake tile to the nose of the field tile above and maintain a constant headlap.

B. Mortar Finish:

1. Place mortar bed along roof edge.

2. Point smooth to a straight edge finish.

3.13 Wall Abutments

A. Cut tile to fit approximately $^1/_2$ in. to base of walls. Point up mortar is optional.

NOTE #17 It may be necessary to remove the lugs from the field tile at wall flashing for proper positioning of cut field tiles. For tiles installed at headwalls, tile shall be installed with approved roof tile adhesive. Fill void at headwall with mortar and point to finish.

3.14 Plumbing Stacks

A. Cut tiles to fit close to plumbing stack. Fill void with mortar and point to finish.

ROOFING APPLICATION STANDARD (RAS) No. 119
INSTALLATION OF MECHANICALLY FASTENED ROOF TILE SYSTEMS
Direct Deck & Horizontal Battens Only
(Preformed Metals With Edge Returns)

1. Scope

This application standard covers the procedures for installation of mechanically fastened roof tile systems on direct deck or horizontal battens only. This standard shall be used in conjunction with the tile manufacturer's Product Approval and RAS 127.

2. Definitions

For definitions of terms used in this application standard, refer to ASTM 1079 and the *Florida Building Code, Building.*

NOTE #1: The following table provides the contractor with the choices available for underlayment systems. These systems can only be used on pitches designated in the table below:

Roof Pitch	Battens or Direct Deck	Choice of Underlayment	Plastic or Compatible Roof Cement at Nails Penetrating Underlayment	Reference
4:12 or greater	Either	1. ASTM D 226 Type II (#30) or ASTM D 2626 (#43) organic base sheet nailed to deck, min. ASTM D 6380, Class M, or WS Type II (#90) organic cap sheet set in Type IV hot asphalt.	Required	3.01 A
	Either	1. Any Product Approved underlayment system with a mechanically fastened base sheet, and cap sheet set in hot, cold, or self-adhered.	Per Product Approval	3.01 B, C, or D
	Either	3. Product Approval listed nail-on single ply underlayment	Per Product Approval	3.01 E

NOTE #2: All tiles shall be interlocking with waterlocks.

NOTE #3: All approved tiles with integral batten-lugs used on slopes greater than 7:12 shall be installed on horizontal battens.

This Roofing Application Standard covers flat, low and high profile roof tiles, using a minimum 3 in. tile headlap, or design limited headlap as specified in the tile manufacturers Product Approval, on minimum $^{15}/_{32}$ in. solid decking nailed in compliance with Chapter 23 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

PART I - GENERAL

1.01

A. Tiles shall not be installed over wet underlayment where moisture prohibits adhesion of mastic, mortar, or adhesive.

PART II - MATERIALS

2.01 Fasteners:

A. Tiles Fasteners

1. All roof tile nails or fasteners, except those made of copper, monel, aluminum, or stainless steel, shall be tested for corrosion in compliance with TAS 114 Appendix E, Section 2 (ASTM G 85), for salt spray for 1000 hrs. Tile fasteners used in coastal building zones, as defined in Chapter 16 (High-Velocity Hurricane Zones), *Florida Building Code, Building* shall be copper, monel, aluminum, or stainless steel.

2. All roof tile fasteners shall be of sufficient length to penetrate a minimum $^1/_2$ in. through the thickness of the deck or batten,whichever is less, or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in.

3. Storm clips and storm clip fasteners – refer to Product Approval with fastener penetration as above.

B. Underlayment Fasteners:

1. Fasteners shall be in compliance with Section 1523 of the *Florida Building Code, Building* (Herein referred to as "Approved Fasteners").

(aa) Nails shall be minimum 12 gage, annular ring shank nails having not less than 20 rings per inch; heads not less than $^3/_8$ in. in diameter; and lengths sufficient to penetrate through the plywood panel or wood plank decking not less than $^3/_{16}$ in., or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in. Nails shall be hot dipped; electro or mechanically galvanized to a thickness sufficient to resist corrosion in compliance with Appendix "E" of TAS 114. All nails shall be Miami-Dade listed for corrosion resistance. All nail cartons or carbon labels shall be labeled to note compliance with corrosion resistance requirements. No roof material shall be fully or partially adhered (not to include mechanically attached) directly to a nailable deck.

(bb) Such fasteners shall be applied through "tin caps" not less than $1^5/_8$ in. and not more than 2 in. in diameter and of not less than 32 gage (0.010 in.) sheet metal. All tin caps shall be Miami-Dade listed for corrosion resistance.

(cc) Prefabricated fastener systems complying of the *Florida Building Code, Building* with Section 1517.5, may be used, provided they are Miami-Dade listed for corrosion resistance.

2.02 Metal Flashing:

A. Flashing materials shall comply with the requirements set forth in Chapter 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*.

1. Metal accessories for roofs shall be not less than 26 gage galvanized, 28 gage stainless steel, 16 ounce copper, 0.024 inch (0.61 mm) thick aluminum, lead sheet with a minimum 2.5 lb/sf or equivalent noncorrosive lead metal alloys or composite materials manufactured for use as roof termination. All composite and nonmetallic flashing materials shall have Product Approval.

2. Metal accessories may be of a manufactured, shop fabricated or field fabricated type, provided the materials and fasteners are in compliance with the minimum requirement of this Code and shall be installed in compliance with methods set forth in RAS 111.

2.03 Asphaltic Adhesive:

A. Asphalt plastic roof cement - conforming to ASTM D 4586, type II, nonasbestos, non-running, heavy body material composed of asphalt and other mineral ingredients.

B. Cold process modified bitumen roofing mastic - conforming to ASTM D 3019, Type III.

C. Asphalt - conforming to ASTM D 312, Type IV.

2.04 Adhesive/Sealant:

A. Structural bonding adhesive - conforming to ASTM 3498.

2.05 Mortar:

A. Materials:

1. Roof tile mortar shall either be a premixed unit having Product Approval and tested in compliance with TAS 123 or a job site mix approved by the building official and in compliance with RAS 113.

B. Mixes:

1. Sand/cement mixes, job mixed or premixed, shall meet ASTM C 270 re-

quirement for Type M mortar (2.25 to 2.5:1 sand to cement ratio).

2. Lightweight aggregate/cement mortar must be premixed and bagged.

2.06 Eave Closure - CHOOSE ONE of the following:

A. Prefabricated EPDM synthetic rubber conforming to ASTM D 1056.

B. Prefabricated metal eave closure must contain minimum $^3/_8$ in. diameter weepholes, spaced not more than 12 in. apart, flush with the underlayment.

C. Prefabricated concrete or clay eave closure.

D. Mortar (color optional) on granular surface underlayments only.

E. Antiponding drip edge.

2.07 Sheathing Material shall conform to APA rated sheathing, in compliance with Chapter 23 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

A. Battens-material to be decay resistant species or pressure treated in compliance with AWPA C2.

1. Battens shall not be bowed or twisted.

2. Horizontal battens shall be a minimum nominal 1 in. by 2 in.

PART III - EXECUTION

3.01 Underlayment Applications - CHOOSE ONE of the following:

NOTE #4: Anchor/base sheet shall have a minimum of two plies in the valleys. A No. 30 or No. 43 can be used as a dry in prior to installing the underlayment with this system.

A. Hot Mop 30/90, Hot Mop 43/90 (see Drawing 1). A No. 30 or No 43 anchor/base sheet ASTM D 226, Type II, or ASTM D 2626 Shall be mechanically attached to the wood deck with approved fasteners spaced in a 12 in. grid staggered in two rows in the field, and 6 in. on center at the laps. Extend anchor/base sheet a minimum of 4 in. up vertical surfaces. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over installed anchor/base sheet, apply one layer of mineral surfaced cap sheet ASTM D 6380 in full 25 #/sq, ± 15 % mopping of asphalt. Asphalt shall be applied uniformly so that felts do not touch felts. End laps shall be a minimum of 6 in.; head laps shall be a minimum of 3 in. and backnailed 12 in. on center with approved nails through tin caps or by Miami-Dade listed prefabricated fasteners.

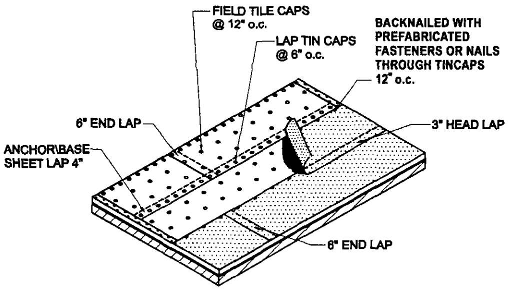
NOTE #5: The above system may be upgraded by hot mopping an interply of ASTM listed fiberglass or perforated organic felt to the anchor sheet before applying the cap sheet. Asphalt application shall be per above specifications.

B. Hot Applied Product Approved Underlayment System (see Drawing 1). An anchor/base sheet shall be mechanically attached to the wood deck with approved fasteners spaced in a 12 in. grid staggered in two rows in the field, and 6 in. on center at the laps or as specified in the underlayment manufacturer's Product Approval. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over installed anchor/base sheet, apply one layer of cap sheet in a full 25#/sq. ± 15 percent mopping of asphalt. Asphalt shall be applied uniformly so that felts do not touch felts. End laps shall be a minimum of 6 in. on center; head laps shall be a minimum of 3 in. and backnailed 12 in. on center with approved nails through tincaps or by prefabricated fasteners in accordance with *Florida Building Code, Building* 1517.5.1 and 1517.5.2.

C. Cold-Applied Product-Approved Underlayment System (See Drawing 1). An anchor /base sheet shall be mechanically attached to the wood deck with approved fasteners spaced in a 12 in. grid staggered in two rows in the field and 6 in. on center at the laps or as specified in the underlayment manufacturers Product Approval. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over anchor/base sheet, apply one layer of cap sheet in a continuous layer of cold process adhesive at the rate of 1.5 gallons per 100 sq. ft. or at the rate if so stated in the Product Approval. Adhesive shall be applied uniformly in accordance with the Product Approval with a squeegee or knotted brush so that felts do not touch felts. Cap sheet side laps shall be a minimum of 6 in.; head laps shall be a minimum of 3 in. and backnailed 12 in. on center with approved nails through tincaps or by prefabricated fasteners in accordance with *Florida Building Code, Building* 1517.5.1 and 1517.5.1.

D. Product-Approved Anchor/Base Sheet/Self-Adhered Underlayment System. The roof cover is terminated at approved metal flashings. Any approved anchor /base sheet as listed in the Product Approval shall be mechanically attached to the wood deck with approved fasteners spaced in a 12 in. grid staggered in two rows in the field and 6 in. on center at the laps or as specified in the underlayment manufacturers Product Approval. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over anchor /base sheet, apply one layer of any Product Approved,self-adhered underlayment in compliance with the self-adhered underlayment manufacturers' approval/requirements.

E. Self-Adhered Underlayment (Single Ply). A single ply underlayment system utilizing any Product approved self-adhered underlayment. The roof cover is terminated at approved metal flashings. Apply one layer of any self-adhered underlayment in compliance with the underlayment manufacturers' approved/requirements.


FIELD TILE CAPS @ 12" o.c.
LAP TIN CAPS @ 6" o.c.
BACKNAILED WITH PREFABRICATED FASTENERS OR NAILS THROUGH TINCAPS 12" o.c.
6" END LAP
3" HEAD LAP
ANCHOR\BASE SHEET LAP 4"
6" END LAP

DRAWING 1
TYPICAL 30/90 HOT MAP

3.02 Drip Edge Metal - CHOOSE ONE of the following:

NOTE #6: Drip edge deck flange shall be primed with ASTM D 41 asphalt primer.

A. Two-ply underlayment systems. (See Drawing 2)

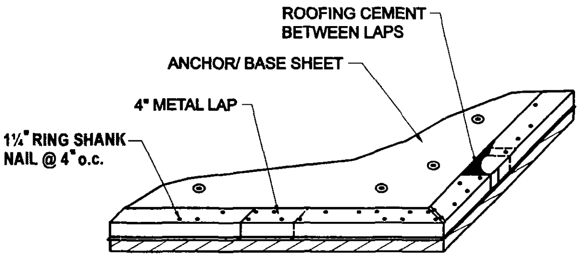
1. Drip edge metal shall be installed over anchor/base sheet, fastened 4 in. on center with approved $1^1/_4$ in. roofing nails or approved fasteners. All joints shall be lapped a minimum of 4 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps.

B. When drip edge metal shall be installed at eaves and gables over a two ply underlayment system: The metal profile shall be placed in a minimum $^3/_{16}$ in. bead of continuous ASTM D 4586 plastic roof cement and fastened 4 in. on center with approved $1^1/_4$ in. roofing nails or approved fasteners. All metal joints shall be lapped a minimum of 4 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps. The metal profile and cap sheet shall be joined with a two ply application of cotton or fiberglass fabric reinforcement, both set in a full bed of approved plastic roof cement. As an alternate, the metal may be stripped in with a 6 in. strip of torch, hot asphalt or cold adhesive polyester reinforced modified bitumen. Joints shall be feathered with cold adhesive, hot asphalt or a torch to enhance water flow across the "backlap."

C. Single-Ply Underlayment Systems:

1. Drip edge metal shall be installed at the eave, over the underlayment or in accordance with the underlayment manufacturer's Product Approval. The metal shall be fastened 4 in. on center with approved $1^1/_4$ in. roofing nails or approved fasteners of compatible metals. All joints shall be lapped a minimum of 4 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps.

2. Strip-in metal with minimum 6 in. strip of the single ply underlayment or in accordance with the underlayment manufacturer's Product Approval, using primer and/or approved compatible mastic if so directed by single ply manufacturer requirements.



DRAWING 2
DRIP EDGE INSTALLATION

3.03 Gable Treatment — CHOOSE ONE of the following:

A. Underlayment Wrapped Gable. (This option shall not be used without installing rake tiles on all rakes.)

1. Trim underlayment at fascia or barge board. Install a peel-and-stick underlayment extending under-

layment beyond rake/gable end. Fold down and seal onto fascia or barge board maximum $2^1/_2$ in. Additionally secure with approved fasteners through tin caps or approved preassembled cap nails in accordance with Section 1517.5 of the *Florida Building Code, Building* spaced at a maximum of 12 in. on center.

B. Metal Finish.

Drip edge metal shall be installed at the gable, over or between the underlayment plies. The metal shall be installed per choices listed above (3.02) to ensure water shedding capabilities of all metal laps.

3.04 Valleys - CHOOSE ONE of the following:

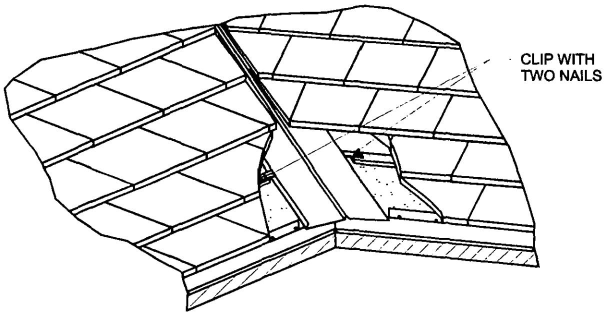
NOTE #7: Where special conditions exist, it may be necessary to increase the width of the valley metal and/or panflashing.

A. Over underlayment install preformed closed valley of a minimum width of 16 in. (24 in. stretch-out) with a minimum $2^1/_2$ in. high center diverter and minimum 1 in. metal edge returns. All joints shall be lapped a minimum of 6 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps (see Drawing 3).

B. Over underlayment install performed open valley with a minimum of 16 in. (24 in. stretch-out) with a minimum 1 in. high twin center diverter and minimum 1 in. metal edge returns. All joints shall be lapped a minimum of 6 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps (see Drawing 4).

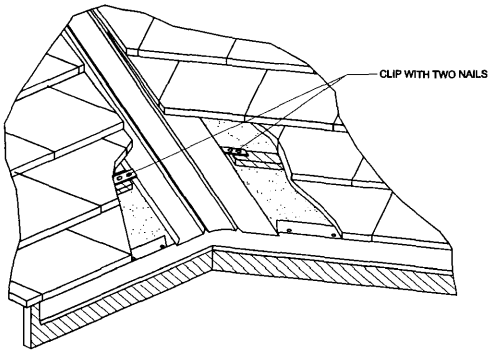
1. Secure with approved clips fabricated from similar or compatible material. Clip 1 in. metal edge returns to either deck or batten strip with 2 approved $1^1/_4$ in. roofing nails through metal strap set inplastic roof cement when clip is direct to deck. Spacing of clips to be maximum 12 in. on center or fastened to each batten.

2. Trim metal at all valley/ridge junctions, ensuring water shedding capabilities onto the valley.



DRAWING 3
PERFORMED CLOSED VALLEY
(NAIL-ON SYSTEM)

3. Install lead soaker at all valley/ridge junctions. Turn lead up a minimum of 1 in. to create a water diverter, ensuring water shedding capabilities onto the valley.



DRAWING 4
VALLEY METAL DETAIL
(NAIL-ON SYSTEM)

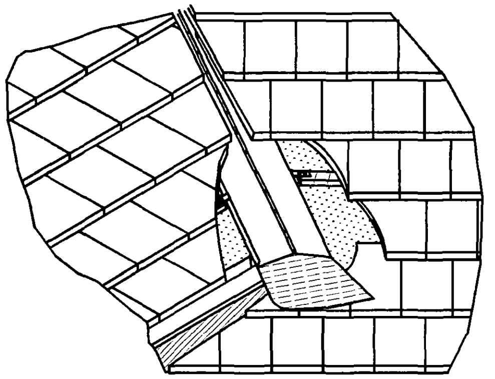
3.05 Valley Termination onto Roof Plane

A. When valley terminates onto roof plane, install in accordance with standard valley flashing procedures:

1. Apply a lead soaker/skirt underneath the eave end of valley to carry water off the valley back onto the field tile (see Drawing 5).

2. If lead skirt is not used, extend complete width of valley metal to carry water off the valley back onto the field tile.

NOTE #8: Where linear footage exceeds 20' it may be necessary to increase the width of the valley metal and/or pan flashing. In all cases, flashing shall be designed to adequately direct water back onto the tiles.



DRAWING 5
NAIL-ON VALLEY SYSTEM
VALLEY METAL OVER TILE

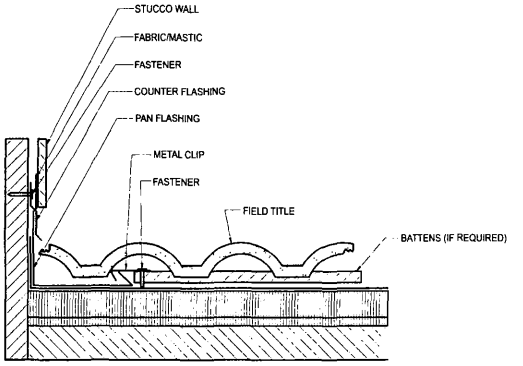
3.06 Flashing and Counterflashings at Wall Abutments (see Drawing 6).

A. Install preformed metal wall tray 5 in. vertical flange, 6 in. base flange with 1 in. metal edge return flush to base of walls over underlayment. Start at lower portion and work up to ensure watertight application.

B. Secure with clips fabricated from compatible material maximum 12 in. on center or spacing of battens. Clip 1 in. metal edge return to deck or batten strip with approved $1^1/_4$ in. roofing nails through the metal strap. Seal all penetrations with plastic roof cement.

C. Fasten vertical metal flange 6 in. on center with approved nails within 1 in. of outside edge. Lap joints a minimum of 4 in. and seal joints with plastic roof cement.

D. Seal along entire edge of vertical metal flange, covering all fastener penetrations with flashing cement and membrane.



DRAWING 6
WALL FLASHING DETAIL
(NAIL-ON SYSTEM)

E. Metal counterflashing shall be installed: lap top flange of base flashing a minimum of 3 in. Fasten metal within 1 in. of outside edge a minimum of 6 in. on center or set metal into reglets and seal thoroughly. Lap joints a minimum of 4 in. ensuring water shedding capabilities and apply plastic roof cement or sealant between the laps.

3.07 Head & Apron Flashing.

A. Install apron flashing a minimum 4 in. on tile surface. Fasten vertical flange of flashing within 1 in. of metal edge with approved fasteners 6 in. on center. Seal along entire edge of vertical metal flange, covering all fastener penetrations with flashing cement and membrane.

3.08 Standard Curb Mounted Skylights, Chimneys, etc.

A. Curbs shall be a minimum of 2 in. x 6 in., and a minimum 2 in. above upper-most adjacent finished tile surface.

B. Install a minimum 12 in. width lead at eave end of each curb.

C. Secure with approved fasteners 6 in. on center, ensuring fasteners will be covered by skylight/hood vent flange.

D. Continue with flexible or rigid flashing on both sides of the curb working up toward ridge. Trim as necessary to ensure water shedding onto field tile.

E. Secure with approved fasteners 6 in. on center.

F. The flexible or ridged flashing at ridge end (upper side) of curb shall extend a minimum 6 in. past each side of curb and shall at least cover the full width of the side flashing immediately below.

G. Seal all fastener penetrations, at skylight or hood vent joints with approved sealant.

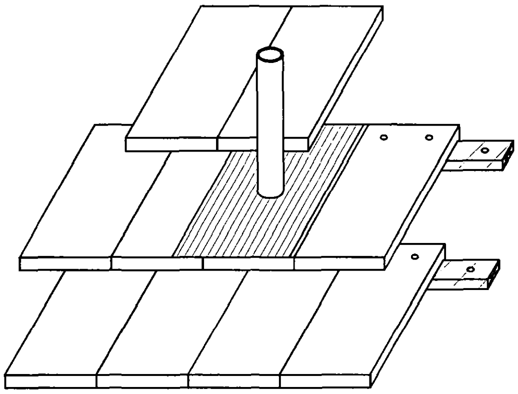
NOTE #9: For self-curbing or prefabricated skylights, curb height shall be min. 6 in. and min 2 in. above most adjacent finished tile surface and installation shall be in accordance with skylight manufacturer's Product Approval. For turbines and other Product approved accessories, refer to the accessory manufacturer's Product Approval.

3.09 Pipes, Stacks, Vents, Etc. (see Drawings 7 and 8).

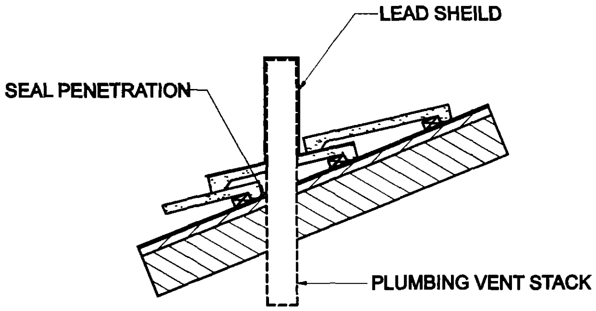
A. Seal around penetration with plastic roof cement or approved sealant.

B. Apply skirt flashing over last field tile cut previously installed extending under the course of tile above the penetration.

C. Flashing shall be 18 in. x 18 in. minimum and be of sufficient



DRAWING 7
PLUMBING STACKS
(NAIL-ON SYSTEMS)



DRAWING 8
PLUMBING STACKS FLASHING
(NAIL-ON SYSTEMS)

width to redirect the water away from penetration.

D. Seal flashing to tile with approved sealant.

NOTE #10: Profile specific ventilators shall be installed as per manufacturer's installation instructions.

3.10 Batten Installation:

Four-foot horizontal battens are required. When utilizing battens, preformed metal flashing with metal edge returns must be used.

NOTE #11: Battens are optional from 4:12 up to and including 7:12 pitch.

A. Install top edge of horizontal batten to horizontal line. Horizontal battens shall be a minimum nominal 1 in. x 2 in.

B. Fasten and secure maximum 24 in. on center with screws or fasteners of sufficient length to penetrate through the sheathing a minimum of $^{3}/_{4}$ in. or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in.

C. Leave $^{1}/_{2}$ in. space between batten ends.

3.11 Tile Installation.

A. Eave Treatment - CHOOSE ONE of the following:

NOTE #12: All fastener Penetrations shall be sealed.

1. Prefabricated EPDM Synthetic Rubber - Install closure strip along eave. Fasten insert each piece at 12 in. on center (see Drawing 9 all fastener penetration shall be sealed with compatible material).

2. Metal Eave Closure - Install closure strip eave. Fasten a minimum 12 in. on center with approved fasteners. If metal is inclusive of drip edge, fasten 4 in. on center. (see Drawing 10).

3. Raised Fascia/Wood Starter Strip when using a 3/4 in. raised fascia, a nominal 2 in. x 2 in. wood starter strip must be installed behind fascia. Choose one of the following:

(aa) Install fascia board approximately $1^{1}/_{2}$ in. above roof deck or a nominal 2 in. x 2 in. wood starter strip at roof edge (see Drawing 11).

(bb) Install 8 in. tapered cant strip at eave behind fascia and/or starter strip to support metal flashing. Install a minimum 8 in. wide antiponding metal flashing to ensure positive drainage over fascia/starter strip. Fasten top edge of flange onto roof and fasten eave edge to raised fascia detail with approved fastener 4 in. on center.

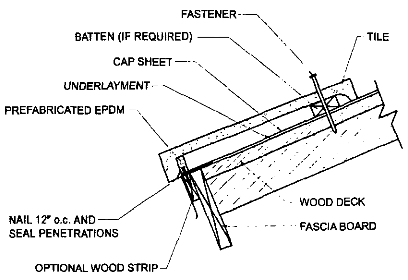
4. Prefabricated Concrete or Clay Eave Closure — fastened in accordance with manufacturer's Product Approval with approved fasteners.

5. Mortar Application - Install mortar to elevate eave edge.

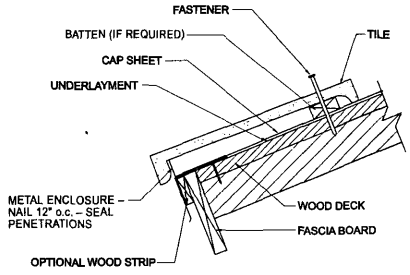
   (aa) Apply mortar along the eave edge, applying enough mortar to elevate the eave end of the tile to be on profile with the remaining roof tile.

   (bb) Point and smooth finish flush to eave line.

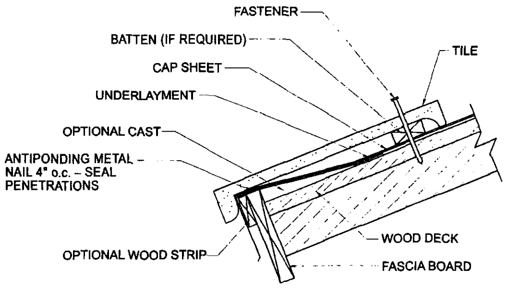
   (cc) Apply minimum $^{3}/_{8}$ in. weephole flush with the roof underlayment shall be formed at the



DRAWING 9
EAVE TILE DETAIL
(NAIL-ON EPDM EAVE ENCLOSURE)



DRAWING 10
EAVE TILE DETAIL
(NAIL-ON METAL EAVE ENCLOSURE)



DRAWING 11
EAVE TILE DETAIL
(NAIL-ON ANTIPONDING ENCLOSURE)

spacing of not less than one weephole per tile.

(dd) Mortar eave closures shall only be used with granular surface underlayment.

B. Storm Clips. Storm clips shall be required at the first course of tile. The use of other alternatives including an adhesive is an acceptable means for fastening the first course of tile as long as it is part of an approved roofing system and meets the requirements for Chapter 16 of the *Florida Building Code, Building* for wind resistance.

NOTE #13: Tile shall be attached to resist the design pressures for the building. See Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* and RAS 127. See Tile manufacturers Product Approval for attachment resistance values, which must exceed the required calculated design pressures of the structure.

3.12 Valleys - CHOOSE ONE of the following:

NOTE #14: It may be necessary to remove the lugs from the field tile and/or install batten extenders at wall and valley flashings for proper positioning of cut field tiles and to facilitate water flow.

A. Preformed Metal With 1 in. Returns:

1. Closed Valley - Miter tile to form straight border on either side of water diverter (see Drawing 5).

2. Open Valley - Miter tile to form straight border on either side of two water diverters (See Drawing 4).

3.13 Hip and Ridge Nailer Boards or Preformed Metal Channel (See Drawing 12 - Details 1, 2, 3 and 4 are also accepted methods of installing Hip and Ridge Nailer Boards.)

A. Wood nailers or preformed metal channel shall be attached in compliance with Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*.

B. Wood nailer boards shall be secured with hot dipped zinc coated galvanized steel straps of a minimum thickness of 1/8 in. by 1 1/4 in. wide. The galvanized steel straps shall be installed at a maximum spacing of 12 in. on center along the length of the ridge nailer boards. Steel straps shall be bent to fit over the ridge nailer boards, and shall be secured to the sheathing with a minimum of six #6-#8 corrosion resistant screws per strap, at a maximum spacing of 4 in. on center.

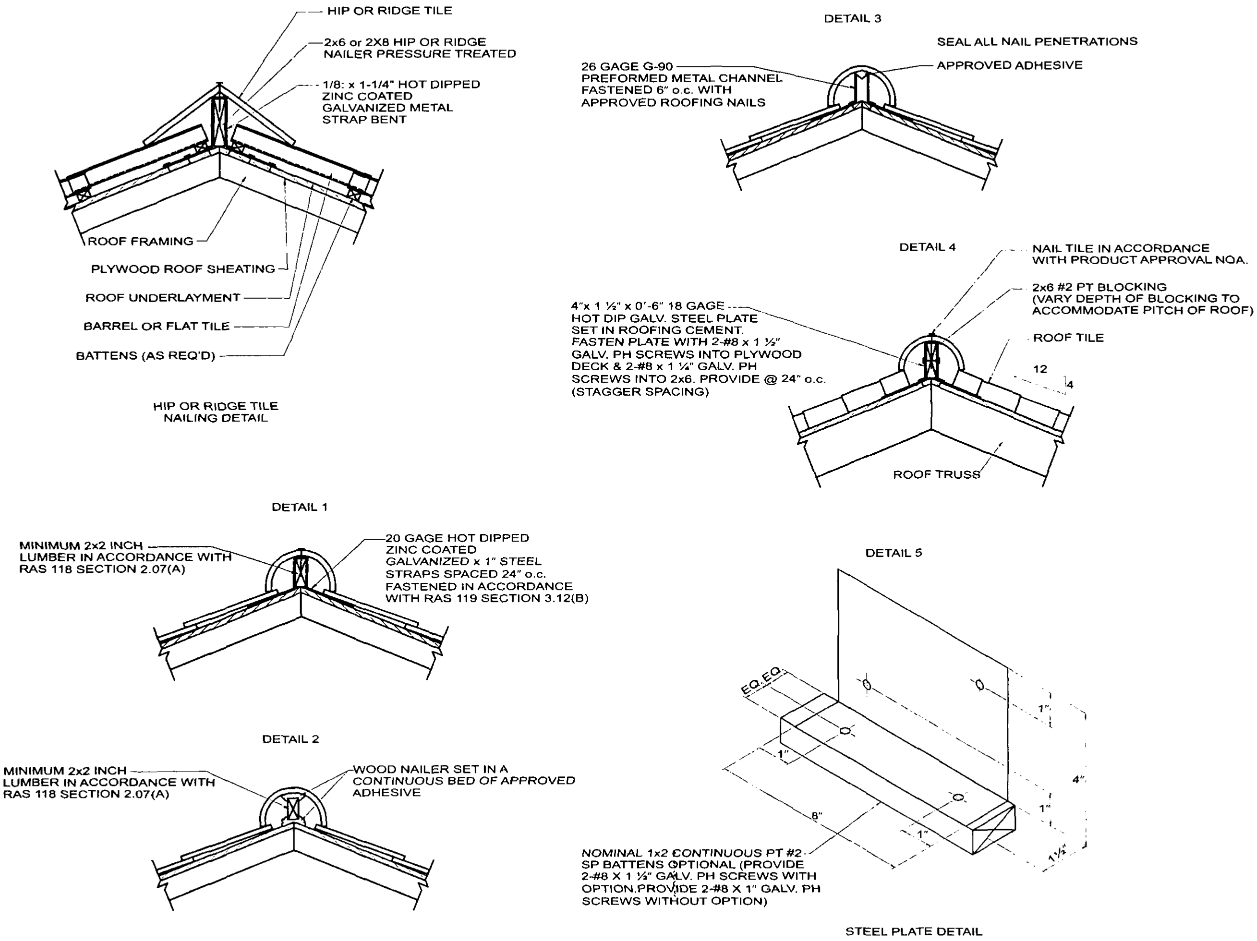
C. Preformed Metal Channel

Preformed Metal Channels shall be secured 6 in. on center with approved fasteners. All fastener penetrations shall be sealed with plastic roof cement.

D. Hip and Ridge Tile Installation - CHOOSE ONE of the following:

1. Self-adhered Membrane

(aa) Install self-adhered membrane over nailer board and seal to tile surface per membrane


HIP OR RIDGE TILE
2x6 or 2X8 HIP OR RIDGE NAILER PRESSURE TREATED
1/8: x 1-1/4" HOT DIPPED ZINC COATED GALVANIZED METAL STRAP BENT
ROOF FRAMING
PLYWOOD ROOF SHEATING
ROOF UNDERLAYMENT
BARREL OR FLAT TILE
BATTENS (AS REQ'D)
HIP OR RIDGE TILE NAILING DETAIL
DETAIL 3
SEAL ALL NAIL PENETRATIONS
APPROVED ADHESIVE
26 GAGE G-90 PREFORMED METAL CHANNEL FASTENED 6" o.c. WITH APPROVED ROOFING NAILS
DETAIL 4
NAIL TILE IN ACCORDANCE WITH PRODUCT APPROVAL NOA.
2x6 #2 PT BLOCKING (VARY DEPTH OF BLOCKING TO ACCOMMODATE PITCH OF ROOF)
4"x 1 ½" x 0'-6" 18 GAGE HOT DIP GALV. STEEL PLATE SET IN ROOFING CEMENT. FASTEN PLATE WITH 2-#8 x 1 ½" GALV. PH SCREWS INTO PLYWOOD DECK & 2-#8 x 1 ¼" GALV. PH SCREWS INTO 2x6. PROVIDE @ 24" o.c. (STAGGER SPACING)
ROOF TILE
12
4
ROOF TRUSS
DETAIL 1
MINIMUM 2x2 INCH LUMBER IN ACCORDANCE WITH RAS 118 SECTION 2.07(A)
20 GAGE HOT DIPPED ZINC COATED GALVANIZED x 1" STEEL STRAPS SPACED 24" o.c. FASTENED IN ACCORDANCE WITH RAS 119 SECTION 3.12(B)
DETAIL 5
EQ. EQ.
1"
1"
8"
1"
4"
1"
1½"
NOMINAL 1x2 CONTINUOUS PT #2 SP BATTENS OPTIONAL (PROVIDE 2-#8 X 1 ½" GALV. PH SCREWS WITH OPTION. PROVIDE 2-#8 X 1" GALV. PH SCREWS WITHOUT OPTION)
STEEL PLATE DETAIL
DETAIL 2
MINIMUM 2x2 INCH LUMBER IN ACCORDANCE WITH RAS 118 SECTION 2.07(A)
WOOD NAILER SET IN A CONTINUOUS BED OF APPROVED ADHESIVE

DRAWING 12
HIP RIDGE TILE
NAILING DETAIL

manufacturer's recommendation.

(bb) Install hip and ridge tiles with corrosion resistant approved nails or screws of sufficient length to penetrate a minimum of $^3/_4$ in. into nailer board lapping tile a minimum of 2 in. (Approved adhesive, in lieu of nails or screws, is permitted when using Detail 2 and 3. When using adhesive, hip and ridge tiles shall be installed in accordance with the adhesive manufacturer's Product Approval).

(cc) Use approved adhesive or clips at overlaps.

2. Mortar

(aa) Set hip and ridge tile in a continuous bed of mortar, lapping tile a minimum 2 in. Ensure bed of mor tar does not protrude in center of hip or ridge junction.Approximately 1 in. of field tile shall extend beyond bed of mortar.

(bb) Install hip and ridge tiles with approved corrosion resistant nails or screws of sufficient length to penetrate a minimum of $^3/_4$ in. into nailer board. (Approved adhesive, in lieu of nails or screws, is permitted when using Details 2 and 3. When using adhesive hip and ridge tiles shall be installed in accordance with the adhesive manufacturer's Product Approval.)

(cc) Point mortar to finish surface.

3.14 Rake/Gable Tile - CHOOSE ONE of the following:

A. Rake/Gable Tile

1. Install first rake tile to exposed length of first course of field tile with factory finish of rake tile towards the eave.

2. Fasten rake tile with a minimum two 10D nails of sufficient length to penetrate the framing a minimum of $^3/_4$ in.

3. Abut each succeeding rake tile to the nose of the tile above and maintain a constant headlap.

B. Mortar Finish:

1. Place mortar bed along roof edge.

2. Point smooth to a straight edge finish.

C. Metal Finish

1. Install prefabricated gable metal with 1 in. water return.

2. Fasten by clipping 12 in. on center or spacing of battens.

NOTE #15: Rake tile application at finishing end may need special consideration to provide proper drainage, i.e. flashing or sealant may be needed.

3.15 Wall Abutments:

A. Cut tile to fit approximately $^1/_2$ in. to base of walls. Point up mortar is optional.

NOTE #16: It may be necessary to remove the lugs from the field tile and/or install batten extenders at wall and valley flashings for proper positioning of cut field tiles. For tiles installed at headwalls, tile shall be installed with approved roof tile adhesive. Fill void at headwall with mortar and point to finish.

ROOFING APPLICATION STANDARD (RAS) No. 120
MORTAR AND ADHESIVE SET TILE APPLICATION

1. Scope

This application standard covers the procedures for installation of mortar or adhesive set roof tile systems. This standard shall be used in conjunction with the tile manufacturer's Product Approval and RAS 127.

2. Definitions

For definitions of terms used in this application standard, refer to ASTM 1079 and the *Florida Building Code, Building.*

NOTE #1: The following table provides the contractor with the choices available for underlayment systems. These systems can only be used on pitches designated in the table below:

Roof Pitch	Choice of Underlayment	Plastic or Compatible Roof Cement at Nails Penetrating Underlayment	Reference
2:12 or greater	1. ASTM D 226 Type II #30 or ASTM D 2626 (#43) inorganic base nailed to deck, min ASTM D 6380, Class M or WS, Type II (#90) organic cap sheet set in Type IV hot asphalt.	Required	3.01 A
	2. Any product approved underlayment system with a mechanically fastened base sheet, and cap sheet set hot, cold, or self adhered.	per Product Approval	3.01 B, C, D or E

This Roofing Application Standard covers flat, low and high-profile roof tile, using a minimum 2 in. tile headlap, or design limited headlap as specified in tile manufacturer's Product Approval. Installed on minimum $^{15}/_{32}$ in. solid decking nailed in compliance with Chapter 23 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

PART I - GENERAL

1.01

A. Tiles shall not be installed over wet underlayment where moisture prohibits adhesion of mastic, mortar, or adhesive.

PART II - MATERIALS

2.01 Fasteners:

A. Tile Fasteners:

1. All roof tile nails or fasteners, except those made of copper, Monel, aluminum, or stainless steel, shall be tested for corrosion in compliance with TAS 114 Appendix E, Section 2 (ASTM G 85), for salt spray for 1000 hours. Tile fasteners used in coastal building zones, as defined in Chapter 16 (High-Velocity Hurricane Zones), *Florida Building Code, Building* shall be copper, monel, aluminum, or stainless steel.

2. All roof tile fasteners shall be of sufficient length to penetrate a minimum $^1/_2$ in. through the thickness of the deck or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in.

B. Underlayment Fasteners:

1. Fasteners shall be in compliance with Section 1523 of the *Florida Building Code, Building* (herein referred to as "Approved Fasteners").

(aa) Nails shall be minimum 12 gage, annular ring shank nails having not less than 20 rings per inch; heads not less than $^3/_8$ in. in diameter; and lengths sufficient to penetrate through the plywood panel or wood plank decking not less than $^3/_{16}$ in., or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in.. Nails shall be hot dipped; electro or mechanically galvanized to a thickness sufficient to resist corrosion in compliance with Appendix E of TAS 114. All nails shall be Miami-Dade listed for corrosion resistance. All nail cartons or carbon labels shall be labeled to note compliance with corrosion-resistance requirements.

(bb) Such fasteners shall be applied through "tin caps" not less than $^{15}/_8$ in. and not more than 2 in. in diameter and of not less than 32 gage (0.010 in.) sheet metal. All tin caps shall be Miami-Dade listed for corrosion resistance.

(cc) Prefabricated fastener systems complying with Section 1517.5, *Florida Building Code, Building* may be used, provided they are Miami-Dade listed for corrosion resistance.

2.02 Metal Flashing:

A. Flashing materials shall comply with the requirements set forth in Chapter 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

1. Metal accessories for roofs shall be not less than 26 gage galvanized, 28 gage stainless steel, 16 ounce copper, 0.024 inch (0.61 mm) thick aluminum, lead sheet with a minimum 2.5 lb/sf or equivalent non- corrosive lead metal alloys or composite materials manufactured for use as roof termination. All composite and nonmetallic flashing materials shall have Product Approval.

2. Metal accessories may be of a manufactured, shop fabricated or field fabricated type, provided the materials and fasteners are in compliance with the minimum requirement of this Code and shall be installed in compliance with methods set forth in RAS 111.

2.03 Asphaltic Adhesive:

A. Asphalt plastic roof cement - conforming to ASTM D 4586, Type II, nonasbestos, nonrunning, heavy body material composed of asphalt and other mineral ingredients.

B. Cold process modified bitumen roofing mastic - conforming to ASTM D 3019, Type III.

C. Asphalt - conforming to ASTM D 312, Type IV.

2.04 Adhesive/Sealant:

A. Structural bonding adhesive - conforming to ASTM 3498.

2.05 Mortar:

A. Materials:

1. Roof tile mortar shall either be a premixed unit having an Product Approval and tested in compliance with TAS 123 or a job site mix approved by the building official and in compliance with RAS 113.

B. Mixes:

1. Sand/cement mixes, job mixed or premixed, shall meet ASTM C 270 requirement for Type M mortar (2.25 to 2.5:1 sand to cement ratio).

2. Lightweight aggregate/cement mortar must be premixed and bagged.

2.06 Eave Closure—CHOOSE ONE of the following:

A. Prefabricated EPDM synthetic rubber conforming to ASTM D 1056.

B. Prefabricated metal eave closure must contain minimum $^3/_8$ in. diameter weepholes, spaced not more than 12 in. apart, flush with the underlayment.

C. Prefabricated concrete or clay eave closure.

D. Mortar (color optional) on granular surface underlayments only.

E. Antiponding drip edge.

2.07 Sheathing Material shall conform to APA rated sheathing, in compliance with Chapter 23 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

A. Battens-material to be decay resistant species or pressure treated in compliance with AWPA LP-2 or better.

PART III - EXECUTION

3.01 Underlayment Applications - CHOOSE ONE of the following:

NOTE #2: Anchor/base sheet shall have a minimum of two plies in the valleys. Cap-sheets for mortar set systems shall be mineral surfaced. A No. 30 or No. 43 can be used as a dry-in prior to installing the underlayment with this system

A. Hot Mop 30/90, Hot Mop 43/90 (See Drawing 1). A No. 30 or No 43 anchor/base sheet ASTM D 226, Type II, or ASTM D 2626 shall be mechanically attached to the wood deck with approved fasteners spaced in a 12 in. grid staggered in two rows in the field, and 6 in. on center at the laps. Extend anchor/base sheet a minimum of 4 in. up vertical surfaces. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over installed anchor/base sheet, apply one layer of mineral surfaced cap sheet ASTM D 6380M in full 25 lb./sq, ± 15 percent mopping of asphalt. Asphalt shall be applied uniformly so that felts do not touch felts. End laps shall be a minimum of 6 in.; head laps shall be a minimum of 3 in. and back nailed 12 in. on center with approved nails through tincaps or by Miami-Dade listed prefacbricated fasteners in accordance with *Florida Building Code, Building* 1517.5.1 and 1517.5.2.

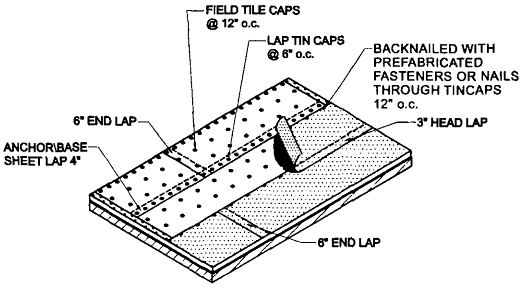
NOTE #3: The above system may be upgraded by hot mopping an interply of ASTM listed fiberglass or perforated organic felt to the anchor sheet before applying the cap sheet. Asphalt application shall be per above specifications.

B. Hot Applied Product Approved Underlayment System (see Drawing 1). An anchor/base sheet shall be mechanically attached to the wood deck (unless directed otherwise by Product Approval) with approved fasteners spaced in a 12 in. grid staggered in two rows in the field, and 6 in. on center at the laps or as specified in the underlayment manufacturer's Product Approval. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over installed anchor/base sheet, apply one layer of cap sheet in a full 25# /sq. ±15 percent mopping of asphalt. Asphalt shall be applied uniformly so that felts do not touch felts. End laps shall be a minimum of 6 in. on center; head laps shall be a minimum of 3 in. and backnailed 12 in. on center with approved nails through tincaps or by prefabricated fasteners in accordance with *Florida Building Code, Building* 1517.5.1 and 1517.5.2.

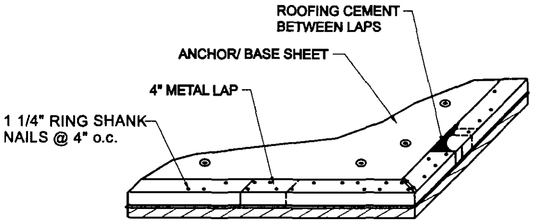
C. Cold Applied Product Approved Underlayment System (see Drawing 1). An anchor /base sheet shall be mechanically attached to the wood deck with approved fasteners spaced in a 12 in. grid staggered in two rows in the field and 6 in. on center at the laps or as specified in the underlayment manufacturers Product Approval. Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over anchor/base sheet, apply one layer of cap sheet in a continuous layer of cold process adhesive at the rate of 1.5 gallons per 100 square feet or at the rate if so stated in the Product Approval. Adhesive shall be applied uniformly in accordance with Product Approval with a squeegee or knotted brush. Cap sheet side laps shall be a minimum of 6 in.; head laps shall be a minimum of 3 in. and backnailed 12 in. on center with approved nails through tincaps or by prefabricated fasteners in accordance with *Florida Building Code, Building* 1517.5.1 and 1517.5.2.

D. Product Approved Anchor/Base Sheet/Self-Adhered Underlayment System. The roof cover is terminated at approved metal flashings. Any approved anchor /base sheet as listed in the Product Approval shall be mechanically attached to the wood deck with approved fasteners spaced in a 12 in. grid staggered in twoOws in the field and 6 in. on center at the laps or as specified in the underlayment manufacturers Product Approval.Anchor/base sheet end laps shall be a minimum of 6 in. and head laps shall be a minimum of 4 in. Over anchor /base sheet, apply one layer of any Product approved, self-adhered underlayment in compliance with the self-adhered underlayment manufacturers' Approval/ Requirements.

E. Self-Adhered Underlayment (Single Ply). A single-ply underlayment system utilizing any Product approved self-adhered underlayment. The roof cover is terminated at approved metal flashings. Apply one layer of any self-adhered underlayment in compliance with the underlayment manufacturers' approved/requirements.


FIELD TILE CAPS @ 12" o.c.
LAP TIN CAPS @ 6" o.c.
BACKNAILED WITH PREFABRICATED FASTENERS OR NAILS THROUGH TINCAPS 12" o.c.
6" END LAP
3" HEAD LAP
ANCHOR\BASE SHEET LAP 4"
6" END LAP

DRAWING 1
TYPICAL 30/90 HOT MAP


ROOFING CEMENT BETWEEN LAPS
ANCHOR/ BASE SHEET
4" METAL LAP
1 1/4" RING SHANK NAILS @ 4" o.c.

DRAWING 2
DRIP EDGE INSTALLATION

3.02 Drip Edge Metal - CHOOSE ONE of the following:

NOTE #4: Drip edge deck flange shall be primed with ASTM D41 asphalt primer.

A. Two-ply underlayment systems (See Drawing 2).

1. Drip edge metal shall be installed over anchor/base sheet, fastened4 in. on center with approved $1^1/_4$ in. roofing nails or approved fasten-ers. All joints shall be lapped a minimum of 4 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps.

B. When drip edge metal shall be installed at eaves and gables over a two ply underlayment system: The metal profile shall be placed in a minimum $^3/_{16}$ in. bead of continuous ASTM D 4586 plastic roof cement and fastened 4 in. on center with approved $1\ ^1/_4$ in. roofing nails or approved fasteners. All metal joints shall be lapped a minimum of 4 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps. The metal profile and cap sheet shall be joined with a two ply application of cotton or fiberglass fabric reinforcement, both set in a full bed of approved plastic roof cement. As an alternate, the metal may be stripped in with a 6" strip of torch, hot asphalt or cold adhesive polyester reinforced modified bitumen. Joints shall be feathered with cold adhesive, hot asphalt or a torch to enhance water flow across the "backlap."

C. Single-Ply Underlayment Systems:

1. Drip-edge metal shall be installed at the eave, over the underlayment or in accordance with the underlayment manufacturer's Product Approval. The metal shall be fastened 4 in. on center with approved 1¼-in. roofing nails or approved fasteners of compatible metals. All joints shall be lapped a minimum of 4 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps.

2. Strip in metal with a minimum 6 in. strip of the single-ply underlayment or in accordance with the underlayment manufacturer's Product Approval, using primer and/or approved compatible mastic if so directed by single ply manufacturer's requirements.

3.03 Valleys - CHOOSE ONE of the following:

NOTE #5: All metal surfaces cap sheet shall be primed with ASTM D 41 asphalt primer.

A. Two ply system - choose one of the following:

1. Preformed or roll metal without returns 16" wide shall be placed over the anchor/base sheet in the valley and shall be fastened 6 in. on center with 12 ga. corrosion-resistant roof nails, or other approved fasteners of compatible metals near the outside edge of the valley metal. All joints shall be lapped a minimum of 6 in. ensuring water shedding capabilities and apply approved plastic roof cement between laps (see Drawing 3).

2. Preformed metal without returns or standard roll metal 16 in. wide shall be placed in the valley on top of the cap sheet and fastened 6 in. on center with 12 ga. corrosion-resistant roof nails, or other approved fasteners of compatible metals near the outside edge of the valley metal. All joints shall be lapped a minimum of 6 in. en-

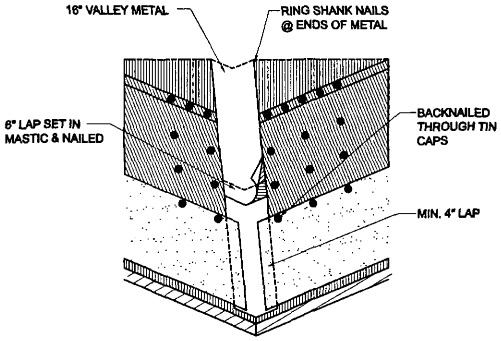
suring water shedding capabilities and apply approved plastic roof cement between laps. The cap sheet shall be joined with 1/8 -in. bed of plastic roof cement and a 4-in. strip of asphalt saturated cotton or fiberglass fabric. The fabric shall be fully embedded in the plastic roof cement. An optional #90 sweat sheet 36 in. wide may be applied prior to the installation of the valley metal and cap sheet.

B. Single-Ply System (See Drawing 4):

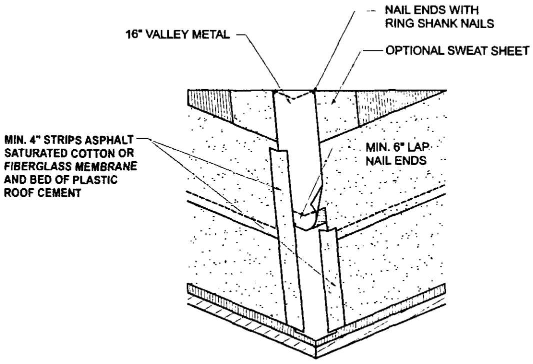
1. Preformed metal without returns 16 in. wide shall be placed in the valley and shall be installed and fastened 6 in. on center with 12 ga., corrosion-resistant roof nails, or other approved fasteners of compatible metals near the outside edge of the valley metal. All joints shall be lapped a minimum of 6 in., ensuring water shedding capabilities and apply approved plastic roof cement between laps. The underlayment shall be joined with a bed of plastic roof cement and a 4-in. strip of asphalt saturated cotton or fiberglass fabric or in accordance with the underlayment manufacturer's Product Approval. The fabric shall be fully embedded in the plastic roof cement. An optional #90 sweat sheet 36 in. wide may be applied prior to the installation of the valley metal and cap sheet.

2. Standard roll metal 16 in. wide shall be placed over the anchor or cap sheet in the valley and shall be fastened 6 in. on center within 1 in. of outside edge with approved 12 ga. corrosion-resistant roof nails, or other approved fasteners of compatible metals near the outside edge of the valley metal. All joints shall be lapped a minimum of 6 in., ensuring water shedding capabilities and apply approved plastic roof cement between laps.

C. Preformed or roll metal without returns 16 in. wide shall be installed on top of the cap sheet, fully embedded in hot


16" VALLEY METAL
RING SHANK NAILS @ ENDS OF METAL
6" LAP SET IN MASTIC & NAILED
BACKNAILED THROUGH TIN CAPS
MIN. 4" LAP

DRAWING 3
TYPICAL VALLEY INSTALLATION


NAIL ENDS WITH RING SHANK NAILS
16" VALLEY METAL
OPTIONAL SWEAT SHEET
MIN. 4" STRIPS ASPHALT SATURATED COTTON OR FIBERGLASS MEMBRANE AND BED OF PLASTIC ROOF CEMENT
MIN. 6" LAP NAIL ENDS

DRAWING 4
VALLEY METAL STRIPPED IN

asphalt or plastic roof cement. All joints shall be water shedding and lapped a minimum of 6 in. in a bed of plastic roof cement. Strips of cap sheet, not less than 8 in. wide shall be lapped over the metal edge, not less than 4 in. and sealed with hot asphalt or plastic roof cement and membrane. An optional #90 sweat sheet 36 in. wide may be applied prior to the installation of the cap sheet and valley metal (see Drawing 4).

3.04 Flashing and Counter Flashings at Wall Abutments

NOTE #6: In no case shall top of vertical flashing be less than 2 in. above tile surface.

NOTE #7: Flashing deck flange shall be primed with ASTM D 41 Asphalt Primer.

NOTE #8: Head/apron flashing may be installed on top of cap sheet in accordance with 3.04.A.3.

A. Two-Ply System - (Choose 1 or 2) (see Drawings 5, 6 and 7).

1. Install minimum 4 in. x 5 in. "L" metal flush to base of walls with 4 in. flange on the anchor/base sheet and fasten 6 in. on center within 1 in. of outside edge. All joints shall be lapped a minimum of 4 in., ensuring water shedding capabilities and apply approved plastic roof cement between laps. Fasten the vertical and horizontal flange of metal within 1 in. of out side edge a minimum of 6 in. on center.

2. Install minimum 4 in. x 5 in. "L" metal on the top ply and fastened 6 in. on center with 12 ga. corrosion resistant roof nails, or other approved fasteners of compatiblemetals within 1 in. of outside edge of the metal. All joints shall be lapped a minimum of 4 in., ensuring water shedding capabilities and apply approved plastic roof cement between laps. Fasten vertical flange of metal within 1 in. of outside edge a minimum of 6 in. on center. Cap sheet shall be joined with a bed of plastic roof cement and a 4 in. strip of asphalt saturated cotton or fiberglass fabric. The fabric shall be fully embedded in the plastic roofing cement.

3. Head/apron flashing may be installed on top of cap sheet. Ensure the deck flange conforms to the pitch of the roof and extend minimum 4 in. onto deck fasten according to 304, A.1. Seal along edge with plastic roof cement and membrane.

4. Seal along top edge within 1 in. of vertical flange, covering all fas tener penetrations with approved plastic roof cement and membrane.

5. When installing optional counter flashing, lap top flange of base flashing minimum 3 in. Fasten metal within 1 in. of the outside edge a minimum of 6 in. on center or set into reglets (secured properly) and thoroughly caulk. Lap joints minimum 4 in. ensuring water shedding capabilities and apply approved plastic roof cement/sealant between laps.

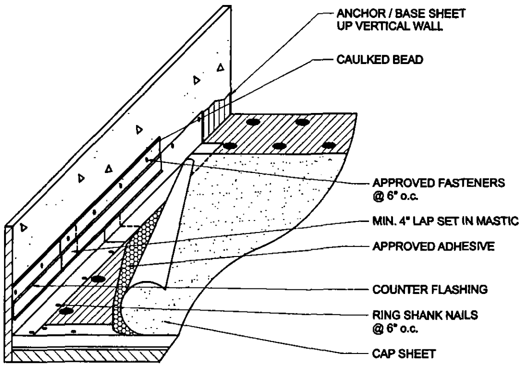
B. Single-Ply System.

1. Install 4 in. x 5 in. "L" metal flush to base of side walls with 4 in. flange over the single-ply underlayment and fasten 6 in. on center near the metals edge. All joints shall be lapped a minimum of 4 in., ensuring water shedding capabilities and apply approved plastic roof cement between laps. Mechanically fasten vertical flange of metal within 1 in. of outside edge a minimum of 6 in. on center near the edge of the metal.

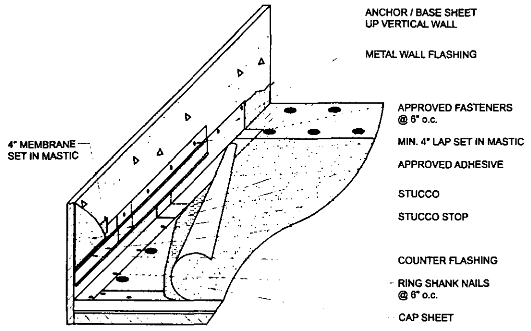
2. Seal along top edge of vertical flange, covering all fastener penetrations with approved plastic roof cement and membrane.

3. All head/apron flashing shall be installed on top of cap sheet. Ensure the deck flange conforms to the pitch of the roof and extend minimum 4 in. onto deck and fastened in accordance with 3.04, B.1. Seal along edge with plastic roof cement and membrane.

4. When installing optional counter flashing, lap top flange of base flashing a minimum of 3 in. Fasten metal within 1 in. of outside edge a minimum of 6 in. on center or set metal into reglets and seal thoroughly. Lap joints a minimum of 4 in. ensuring water shedding capabilities and apply plastic roof cement or sealant between the laps.


ANCHOR / BASE SHEET UP VERTICAL WALL
CAULKED BEAD
APPROVED FASTENERS @ 6" o.c.
MIN. 4" LAP SET IN MASTIC
APPROVED ADHESIVE
COUNTER FLASHING
RING SHANK NAILS @ 6" o.c.
CAP SHEET

DRAWING 5
WALL FLASHING DETAIL
(COUNTER FLASHING WITH CAULKED BEAD)


ANCHOR / BASE SHEET UP VERTICAL WALL
METAL WALL FLASHING
APPROVED FASTENERS @ 6" o.c.
4" MEMBRANE SET IN MASTIC
MIN. 4" LAP SET IN MASTIC
APPROVED ADHESIVE
STUCCO
STUCCO STOP
COUNTER FLASHING
RING SHANK NAILS @ 6" o.c.
CAP SHEET

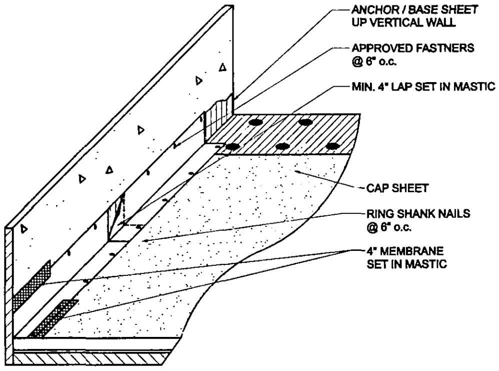
DRAWING 6
WALL FLASHING DETAIL
(STUCCO STOP DETAIL)

3.05 Standard Curb Mounted Skylights, Chimneys, etc. (see Section 3.04 above).

A. Curbs shall be a minimum 2 in. x 6 in., and a minimum 2 in. above uppermost adjacent finished tile surface.

B. Flashing shall follow instructions in 3.04 A or B in this System.

NOTE #9: For self-curbing or prefabricated skylights, curb height


ANCHOR / BASE SHEET UP VERTICAL WALL
APPROVED FASTNERS @ 6" o.c.
MIN. 4" LAP SET IN MASTIC
CAP SHEET
RING SHANK NAILS @ 6" o.c.
4" MEMBRANE SET IN MASTIC

DRAWING 7
WALL FLASHING DETAIL
(WALL FLASHING OVER CAP SHEET)

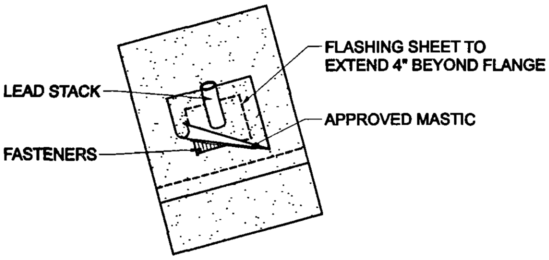
shall be min. 6 in. and in 2 in. above most adjacent finished tile surface and installation shall be in accordance with skylight manufacturer's Product Approval. For turbines and other Product approved accessories refer to the accessories manufacturer's Product Approval.

3.06 Pipes, Stacks, Vents, etc. (see Drawings 8 & 9).

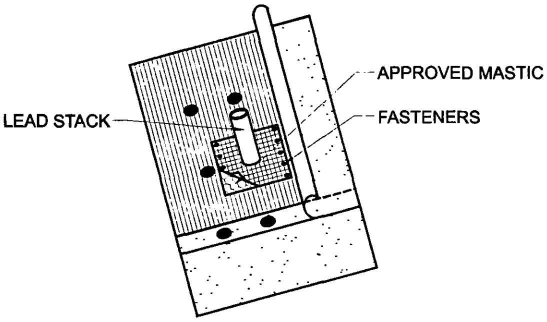
A. Apply approved plastic roof cement around base of protrusion and on the bottom side of metal flanges sealing unit base flashing to the underlayment.

B. Nail all sides within 1 in. of outside edge of base flashing 6 in. on center. Make certain base is flush to deck.

NOTE #10: If pipes, vents and/or stacks are installed after finished cap sheet has been applied, follow instructions in 3.06 A & B. Cap sheet and metal flange shall be stripped in with at least the same cap sheet felt in use on this system. Stripping must extend at least 4 in. beyond flange in all directions.



LEAD STACK DETAIL
(OVER THE CAPSHEET)
DRAWING 8



LEAD STACK DETAIL
(OVER THE BASE SHEET)
DRAWING 9

3.07 Tile Installation:

A. Eave Treatment - CHOOSE ONE of the following:

NOTE #11: All fastener penetrations shall be sealed.

1. Prefabricated EPDM Synthetic Rubber - Install closure strip along eave. Fasten each piece

at 12 in. on center (see Drawing 10 all fastener penetration shall be sealed with compatible material).

2. Metal Eave Closure - Install closure strip along eave. Fasten a minimum 12 in. on center with approved fasteners. If metal is inclusive of drip edge, fasten 4 in. on center (see Drawing 11).

3. Raised Fascia/Wood Starter Strip when using a $^3/_4$ in. raised fascia, a nominal 2 in. x 2 in. wood starter strip must be installed behind fascia.

    (aa) Install fascia board approximately $1^1/_2$ in. above roof deck or a nominal 2 in. x 2 in. wood starter strip at roof edge (see Drawing 12).

    (bb) Install 8 in. tapered cant strip at eave behind fascia and/or starter strip to support metal flashing. Install a minimum 8 in. wide antiponding metal flashing to ensure positive drainage over fascia/starter strip. Fasten top edge of flange onto roof and fasten eave edge to raised fascia detail with approved fasteners 4 in. on center.

4. Prefabricated Concrete or Clay Eave Closure - fastened in accordance with manufacturer's Product Approval with approved fasteners.

NOTE #12: All fastener penetrations shall be sealed.

5. Mortar Application - Install mortar to elevate eave edge.

    (aa) Apply mortar along the eave edge, applying enough mortar to elevate the eave end of the tile to be on profile with the remaining roof tile.

    (bb) Point and smooth finish flush to eave line.

    (cc) Apply minimum $^3/_8$ in. weep hole flush with the roof underlayment at spacing of not less than one weephole per tile.

    (dd) Mortar eave closures shall only be used with granular surface underlayment.

NOTE #13: Tile shall be attached to resist the design pressures for the building. See Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* and RAS 127. See tile manufacturer's Product Approval for attachment resistance values, which must exceed the required calculated design pressures of the structure.

A. Mortar /Adhesive Application: Low, High and Flat Profile Tile (see Drawings 13).

1. Set tile in a bed of approved mortar/adhesive. Apply 10 in. minimum length trowel of mortar or required amount of adhesive vertically un-

der pan. For flat tile place mortar/adhesive vertically adjacent to the overlock of the tile being installed. Do not apply mortar under headlug of tile, or onto the underlock of adjacent tile. (Unless otherwise specified in adhesive's manufacturers Product Approval)

2. Use half starter/finisher tile when provided or cut/break tile for proper staggering of tile courseswhen using the staggered/cross bond method of installation.

3. Set tile in stepped course fashion or in a horizontal and/or vertical fashion when utilizing straight bond method.

4. Lay succeeding course of field tile in same manner.

5. Cut/break field tile to form straight edge at center of hip/ridge.

NOTE #14: Mortar or adhesive set tile shall be applied at inclines of 2:12 and greater. For pitches of 6 in.: 12 in. up to and including 7 in.: 12 in. nail every tile in the first course and every third tile in every fifth course in addition to mortar or adhesive. For pitches above 7 in.:12 in. nail every tile in addition to mortar or adhesive. Apply approved flashing cement to seal all nail penetrations. Fastening requirements at slope of 7:12 or less for Two-Piece Barrel application applies to pan tiles only. No mortar or adhesive products shall be applied in a manner which prevents drainage of water under tiles.

B. Two-Piece Barrel Tile Mortar or Adhesive Application (see Drawing #14):

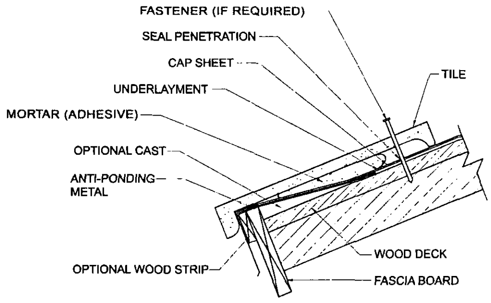
1. Apply 10 in. mason's trowel of mortar or required amount of adhesive in accordance with the tile system Product Approval vertically over chalk line and under center of each pan with narrow end facing down roof.

2. Place bed of mortar or required amount of adhesive in accordance with the tile system Product Approval along inside edges of pans and set covers with wide end facing down roof.

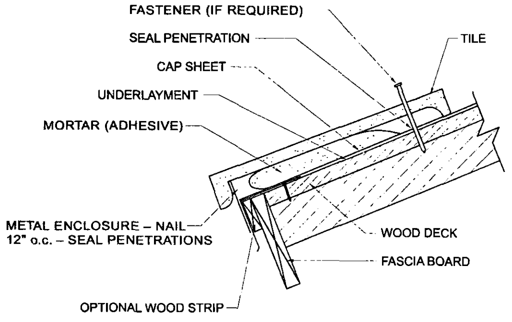
3. Point mortat to form acceptable straight-edge finish ensuring contact along edges. Cosmetic use of mortar is acceptable for use with adhesive set tiles.

4. Lay succeeding courses of field tile in same manner. Bed of mortar or adhesive should make contact with head of lower course of tile and underside of tile being set.

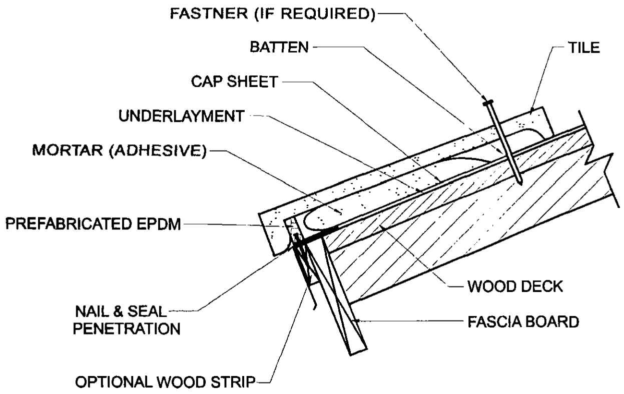
5. Cut/break field tile to form straight edge at center of hip/ridge.



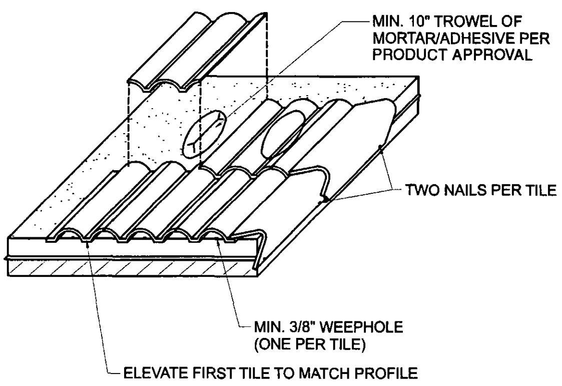
DRAWING 10
EAVE TILE DETAIL
EPDM EAVE CLOSURE



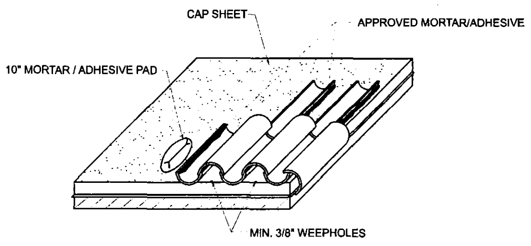
DRAWING 11
EAVE TILE DETAIL
(METAL EAVE ENCLOSURE)



DRAWING 12
EAVE TILE DETAIL
ANTIPONDING METAL


MIN. 10" TROWEL OF MORTAR/ADHESIVE PER PRODUCT APPROVAL
TWO NAILS PER TILE
MIN. 3/8" WEEPHOLE (ONE PER TILE)
ELEVATE FIRST TILE TO MATCH PROFILE

DRAWING 13
MORTAR (ADHESIVE) SET TILE



DRAWING 14
BARREL TILE INSTALLATION

3.08 Valleys - CHOOSE ONE of the following:

NOTE #15: It may be necessary to remove the lugs from the field tile at walls and valley flashings for proper positioning of cut field tiles.

A. Standard Roll Valley

1. Closed valley - Miter tile to meet at center of valley.

2. Open Valley - Chalk a line a minimum 2 in. on both sides of the valley center. Place bed of mortar along outside edge of chalk lines. Miter tile to form straight border and point to match tile surface.

B. Preformed Metal Without Returns

1. Closed valley - Miter tile to form straight border on either side of water diverter.

2. Open Valley - Miter tile to form straight border on either side of two water diverters.

3.09 Hip Starter - CHOOSE ONE of the following:

A. Prefabricated hip starter.

1. Miter tile as hip starter to match eave lines.

B. Use standard hip tiles as starter.

3.10 Hip and Ridge Nailer Boards or Preformed Metal Channel (see Drawing 15) - Details 1, 2, 3 and 4 are also accepted methods of installing Hip and Ridge Nailer Boards. (Approved adhesive in lieu of nails or screws, is permitted when using Details 2 and 3.)

A. Wood nailers or preformed metal channel shall be required and attached in compliance with Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

B. Wood nailer boards shall be secured with hot dipped zinc coated galvanized steel straps of a minimum thickness of $^1/_8$ in. by 1 $^1/_4$ in. wide. The galvanized steel straps shall be installed at a maximum spacing of 12 in. on center along the length of the ridge nailer boards. Steel straps shall be bent to fit over the ridge nailer boards, and shall be secured to the sheathing with a minimum of six #6-#8 corrosion resistant screws per strap, at a maximum spacing of 4 in. on center.

C. Preformed Metal Channel

Preformed Metal Channels shall be secured 6 in. on center with approved fasteners. All fastener penetrations shall be sealed with plastic roof cement.

D. Hip and Ridge Tile Installation - CHOOSE ONE of the following:

1. Self-adhered Membrane:

(aa) Install self-adhered membrane over nailer board and seal to tile surface per membrane manufacturer's recommendation.

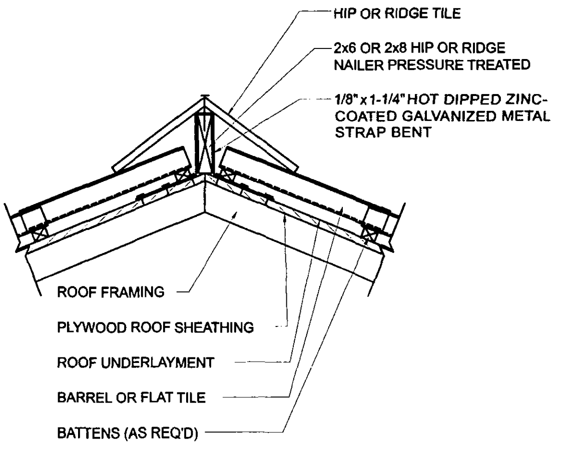
(bb) Install hip and ridge tiles with corrosion resistant approved nails or screws and of sufficient length to penetrate a minimum of $^{3}/_{4}$ in. into nailer board lapping tile a minimum of 2 in. (Approved adhesive, in lieu of nails or screws, is permitted when using Details 2 and 3. When using adhesive hip and ridge tiles shall be installed in accordance with the adhesive manufacturer's Product Approval.)

(cc) Use approved adhesive or clips at overlaps.

2. Mortar:

(aa) Set hip and ridge tile in a continuous bed of mortar, lapping tile a minimum 2 in. Ensure bed of mortar does not protrude in center of hip or ridge junction. Approximately 1 inch (25 mm) of field tile shall extend beyond bed of mortar.

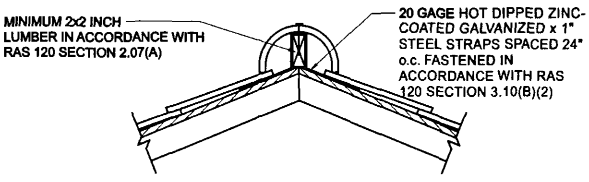
(bb) Install hip and ridge tiles with approved corrosion resistant nails or screws of sufficient length to penetrate a minimum of ¾ in. into nailer board. (Approved adhesive, in lieu of nails or screws, is permitted when using Details 2 and 3. When using adhesive, hip and ridge tiles shall be installed in accordance with the adhesive manufacturer's Product Approval.)


HIP OR RIDGE TILE
2x6 OR 2x8 HIP OR RIDGE NAILER PRESSURE TREATED
1/8"x1-1/4" HOT DIPPED ZINC-COATED GALVANIZED METAL STRAP BENT
ROOF FRAMING
PLYWOOD ROOF SHEATHING
ROOF UNDERLAYMENT
BARREL OR FLAT TILE
BATTENS (AS REQ'D)

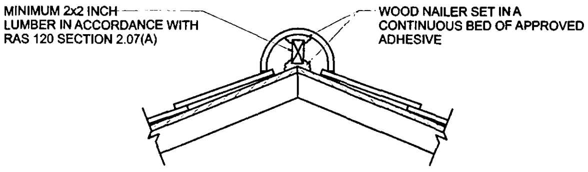
HIP OR RIDGE TILE
NAILING DETAIL

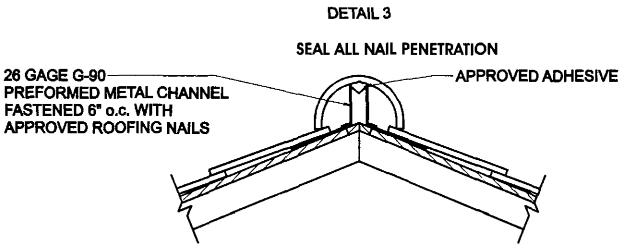
DRAWING 15
RIDGE BLOCKING DETAIL

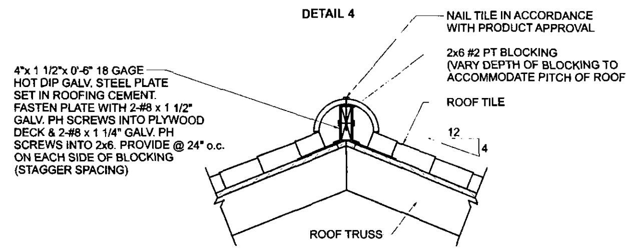
DETAIL 1

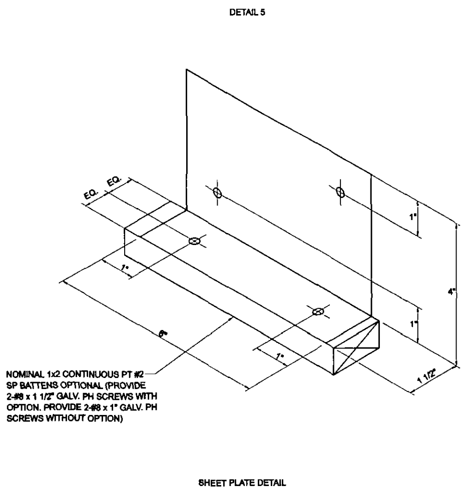

MINIMUM 2x2 INCH LUMBER IN ACCORDANCE WITH RAS 120 SECTION 2.07(A)
20 GAGE HOT DIPPED ZINC-COATED GALVANIZED x 1" STEEL STRAPS SPACED 24" o.c. FASTENED IN ACCORDANCE WITH RAS 120 SECTION 3.10(B)(2)

DETAIL 2


MINIMUM 2x2 INCH LUMBER IN ACCORDANCE WITH RAS 120 SECTION 2.07(A)
WOOD NAILER SET IN A CONTINUOUS BED OF APPROVED ADHESIVE


DETAIL 3
SEAL ALL NAIL PENETRATION
26 GAGE G-90 PREFORMED METAL CHANNEL FASTENED 6" o.c. WITH APPROVED ROOFING NAILS
APPROVED ADHESIVE


DETAIL 4
NAIL TILE IN ACCORDANCE WITH PRODUCT APPROVAL
2x6 #2 PT BLOCKING (VARY DEPTH OF BLOCKING TO ACCOMMODATE PITCH OF ROOF)
4"x 1 1/2"x 0'-6" 18 GAGE HOT DIP GALV. STEEL PLATE SET IN ROOFING CEMENT. FASTEN PLATE WITH 2-#8 x 1 1/2" GALV. PH SCREWS INTO PLYWOOD DECK & 2-#8 x 1 1/4" GALV. PH SCREWS INTO 2x6. PROVIDE @ 24" o.c. ON EACH SIDE OF BLOCKING (STAGGER SPACING)
ROOF TILE
12
4
ROOF TRUSS


DETAIL 5
EQ.
EQ.
1"
1"
1"
1"
4"
6"
1 1/2"
NOMINAL 1x2 CONTINUOUS PT #2 SP BATTENS OPTIONAL (PROVIDE 2-#8 x 1 1/2" GALV. PH SCREWS WITH OPTION. PROVIDE 2-#8 x 1" GALV. PH SCREWS WITHOUT OPTION)
SHEET PLATE DETAIL

DETAIL 5
SHEET PLATE DETAIL

(cc) Point mortar to finish surface.

3.11 Rake/Gable - CHOOSE ONE of the following:

A. Rake/Gable Tile:

1. Install first rake tile the exposed length of first course of field tile with factory finish of rake tile towards the eave.
2. Fasten each rake tile with aminimum of two 10D nails of sufficient length to penetrate the framing a minimum of $^{3}/_{4}$ in.

3. Abut each succeeding rake tile to the nose of the field tile above and maintain a constant headlap.

B. Mortar Finish:

1. Place mortar bed along roof edge.

2. Point smooth to a straight edge finish.

3.12 Wall Abutments

A. Cut tile to fit approximately $^{1}/_{2}$ in. to base of walls. Point-up mortar is optional.

B. Headwall abutment shall be pointed with mortar.

3.13 Plumbing Stacks

A. Cut tiles to fit close to plumbing stack. Fill void with mortar and point to finish.

ROOFING APPLICATION STANDARD (RAS) No. 127

PROCEDURE FOR DETERMINING THE MOMENT OF RESISTANCE AND MINIMUM CHARACTERISTIC RESISTANCE LOAD TO INSTALL A TILE SYSTEM ON A BUILDING OF A SPECIFIED ROOF SLOPE AND HEIGHT

1. Scope

This standard covers the procedure for determining the Moment of Resistance (M_r) and Minimum Characteristic Resistance Load (F') to install a tile system on buildings of a specified roof slope and height. Compliance with the requirements and procedures herein specified, where the pressures (P) have been determined based on Table 1 of this standard, do not require additional signed and sealed engineering design calculation. All other calculations must be prepared, signed and sealed by a professional engineer or registered architect.

2. How to determine the Moment Resistance (M_r) (Moment Based Systems)

2.1 Determine the minimum design wind pressures for the field, perimeter and corner areas (P1, P2 and P3, respectively) using the values given in Table 1 or those obtained by engineering analysis prepared, signed and sealed by a professional engineer or registered architect based on ASCE 7.

2.2 Locate the aerodynamic multiplier (λ) in tile Product Approval.

2.3 Determine the restoring moment due to gravity (M_g) per Product Approval.

2.4 Determine the attachment resistance (M_f) per Product Approval.

2.5 Determine the Moment of Resistance (M_r) per following formula:

$$M_r = (P \times \lambda) - M_g$$

2.6 Compare the values for M_r, with the values for M_f, noted in the Product Approval. If the M_f values are greater than or equal to the M_r values, for each area of the roof [i.e., field P(1), perimeter P(2) and corner P(3) areas], then the tile attachment method is acceptable.

3. How to determine the Minimum Characteristic Resistance Load (F') (Uplift Based System)

3.1 Determine the minimum design pressures for the field, perimeter and corner areas [P(1), P(2) and P(3), respectively] using the values given in Table 1 or those obtained by engineering analysis prepared, signed and sealed by a professional engineer or registered architect based on the criteria set forth in ASCE 7.

3.2 Determine the angle (θ) of roof slope, from Table 1.

3.3 Determine the length (l), width (w) and average tile weight (W) of tile, per Product Approval.

3.4 Determine the required uplift resistance (F_r) per following formula:

$$F_r = [(P \times l \times w) - W] \times \cos\theta$$

3.5 Compare the values for F_r with the values for F' noted in the Product Approval. If the F' values are greater than or equal to the F_r values, for each area of roof [i.e., field P(1) perimeter (P(2) and corner P(3) areas], then the tile attachment method is acceptable.

TABLE 1
MINIMUM DESIGN WIND UPLIFT PRESSURES IN PSF FOR FIELD (P(1), PERIMETER (P(2) AND CORNER (P(3) AREAS OF ROOFS FOR EXPOSURE C BUILDINGS WITH A ROOF MEAN HEIGHT AS SPECIFIED[1]

ROOF SLOPE	> 2:12 to ≤ 6:12			> 6:12 to ≤12:12	
Roof mean height	P(1)	P(2)	P(3)[2]	P(1)	P(2) & P(3)
<=20’	-45.1	-78.6	-116.2	-49.1	-57.5
>20’ to <=25’	-47.3	*-82.3*	-121.8	-51.2	-60.4
>25’ to <=30’	-49.2	-85.7	-126.8	-53.6	-62.9
>30’ to <=35’	-50.9	-88.5	-130.9	-55.3	-65.0
>35 to <=40’	-52.3	-91.0	-134.6	-56.9	-66.8

[1] Calculated in accordance with ASCE 7.05 (Wind Speed: 146 mph).

[2] For Hip Roofs with slope <=5.5: 12, P(3) shall be treated as P(2). [Mod 2014r/2104r]

TABLE 2
WHERE TO OBTAIN INFORMATION

Description	**Symbol**	**Where to find**
Design Pressure	P(1) or P(2) or P(3)	Table 1 or by an engineer analysis prepared, signed and sealed by a professional engineer based on ASCE 7
Mean Roof Height	H	Job Site
Roof Slope	θ	Job Site
Aerodynamic Multiplier	λ	Product Approval
Restoring Moment due to Gravity	M_g	Product Approval
Attachment Resistance	M_f	Product Approval
Required Moment Resistance	M_r	Calculated
Minimum Characteristic Resistance Load	F'	Product Approval
Required Uplift Resistance	F_r	Calculated
Average Tile Weight	W	Product Approval
Tile Dimensions	l=length w=width	Product Approval

All calculations must be submitted to the building official at the time of permitting.

ROOFING APPLICATION STANDARD (RAS) No. 128

STANDARD PROCEDURE FOR DETERMINING APPLICABLE WIND DESIGN PRESSURES FOR LOW SLOPE ROOF

1. Scope

1.1 This roofing application standard has been developed to provide a responsive method of complying with the requirements of Chapters 15 & 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*. Compliance with the requirements and procedures herein specified, where the pressures (P) have been determined based on Table R128-1 of this standard, do not require additional signed and sealed engineering design calculations. All other calculations must be prepared, signed and sealed by a professional engineer or registered architect.

2. Definitions

2.1 For definitions of terms used in this application standard, refer to ASTM D 1079 and the *Florida Building Code, Building.*

3. Applicability

3.1 This application standard applies to:
a. exposure C category buildings; and
b. building heights of less than or equal to 40 feet; and
c. roof incline (pitch) is not greater than $^1/_2$ in.:12 in.

3.2 Using Table 1 below, determine the minimum design pressure for each respective roof area, which corresponds to the applicable roof height range.

3.3 Referencing the selected Roof Assembly Product Approval, check that the listed maximum allowable design pressure for the particular approved system meets or exceeds those listed in Table 1 above.

TABLE 1
MINIMUM DESIGN WIND UPLIFT PRESSURES, IN PSF FOR FIELD (P(1), PERIMETER (P(2) AND CORNER (P(3) AREAS OF ROOFS FOR EXPOSURE 'C' BUILDINGS

Roof mean height (below)	P(1) Field	P(2) (Perimeter)	P(3) (Corners)
20	-49.2	-82.6	-124.3
25	-51.4	-86.3	-129.9
30	-53.6	-89.9	-135.3
35	-55.2	-92.7	-139.5
40	-56.9	-95.4	-143.6

[1] Calculated in accordance with ASCE 7.

ROOFING APPLICATION STANDARD (RAS) No. 130

INSTALLATION CRITERIA FOR WOOD SHINGLES AND SHAKES APPLICATION

1. Scope

1.1 This application standard provides the minimum installation criteria for wood shingles and shakes application.

2. Definitions

2.1 For definitions of terms used in this application standard, refer to ASTM D 1079 and the *Florida Building Code, Building*.

3. General

3.1 Maximum exposure for wood shingles and shakes shall comply with Table 1 herein, unless specifically specified in the roof assemblies Product Approval.

3.2 Wood shingles and shakes may be applied over solid or spaced sheathing. In spaced sheathing applications, the first 36 in. above the eave line shall be solidly sheathed. All wood decks shall comply with the provisions set forth in Chapters 15 and 23 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*.

3.3 Wood shingles and shakes shall not be installed on roof mean heights greater than 33 feet, unless specifically specified in the roof assemblies Product Approval.

TABLE 1
MAXIMUM EXPOSURE TO WEATHER FOR WOOD SHINGLES AND SHAKES IN INCHES

Shingle Length			
Roof Slope	16 in.	18 in.	24 in.
3 1/2:12 to 4:12	3.75 in.	4.25 in.	5.75 in.
4:12 or greater	5 in.	5.5 in.	7.5 in
Shake Length			
		18 in.	24 in.
4:12 or greater		7.5 in.	10 in.

1. Calculated in accordance with ASCE 7.

4. Wood Shingles

4.1 Underlayment

Solid Sheathing: Two plies of ASTM D 226, Type 1 felt overlapped 19 in., or a single layer of ASTM D 226 Type II felt overlapped a minimum of 4 in. on side laps, and 6 in. on the end laps. Fastened with corrosion resistant 12 ga. roofing nails through tin caps. Fasten with two staggered rows in the field of the sheet with a maximum fastener spacing of 12 in. o.c., and one row at the laps fastened 6 in. o.c.

Spaced Sheathing: Underlayment shall be installed at a minimum of 36 in. wide at the eave line, and shall be a minimum of two plies of ASTM D 226, Type I felt overlapped 19 in., or a single layer of ASTM D 226 Type II felt overlapped a minimum of 4 in. on side laps, and 6 in. on the end laps. Fastened with corrosion resistant 12 ga. roofing nails through tin caps. Fasten with two staggered rows in the field of the sheet with a maximum fastener spacing of 12 in. o.c., and one row at the laps fastened 6 in. o.c., at a minimum of 36 in. from the eave of the roof.

Roofing nails shall be of sufficient length to penetrate through the plywood panel or wood plank decking not less than $^{3}/_{16}$ in., or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in.

4.2 Edge metal shall comply with Section 1517.6 of the *Florida Building Code, Building*, and RAS 111.

4.3 Valleys may be installed open or closed. A 36 in. wide sheet of minimum ASTM D 226 Type II organic felt shall be installed over the underlayment and centered in the valley, fastened 6 in. o.c. through tin-caps at each edge of the sheet. Minimum end laps shall be 12 in. and fully adhered with approved flashing cement.

4.4 Valley metals shall comply with the Section 1517.6 of the *Florida Building Code, Building*. Valley metal shall be preformed with side returns and a minimum 1 in. high center water diverter. Valley metal shall have a minimum formed width of 20 in. Valley metal shall be fastened with minimum 2 in. wide metal clips spaced 12 in. o.c. Metal clips shall be fabricated of similar metal and fastened with minimum two approved $1^{1}/_{4}$ in. annular ring shank roofing nails at every clip (see Detail A).

4.5 Metal laps shall be a minimum of 12 in., and shall be sealed with approved flashing cement. For open valley installations, the wood shingles are to be cut to form a straight edge. The open area of the valley shall be no less than 4 in. and no more than 8 in. wide. For closed valley installations, the wood shingles are to be miter cut along the center water diverter. Wood shingle fasteners shall be kept back at least 8 in. from the valley centerline. Wider wood shingles and the positioning of the fasteners higher at the valley may be required.

4.6 The maximum exposure to the weather for wood shingle applications shall comply with Table 1 herein.

4.7 An optional interlayment sheet may be installed between wood shingles in solid sheathing applications. Interlayment shall be required in all spaced sheathing applications. Interlayment shall be a minimum of ASTM D 226, Type I felt with a minimum width of 18 in. and shall be applied between each succeeding course of wood shingles. Interlayment shall be fastened on the upper edge of the sheet. The bottom edge of the interlayment shall be positioned above the butt edge of each course of wood shingles, a distance equal to triple the weather exposure of the wood shingles. Extend interlayment up vertical surfaces a minimum of 4 in. No felt shall be exposed.

4.8 The beginning or starter course of wood shingles at the eave line shall be doubled as a minimum. The wood shingles shall be project a minimum $^{3}/_{4}$ in. to a maximum of 2 in. beyond the drip edge at both eaves and rakes. Spacing between shingles (joints or key ways) shall be a minimum of $^{1}/_{4}$ in. and a maximum of $^{3}/_{8}$ in. Shingles shall be positioned so that they cover the joints in the preceding course and adjacent courses shall be offset a minimum of 1 $^{1}/_{2}$ in. In any three courses (adjacent), no two joints should be directly aligned (see Detail B).

4.9 Each shingle shall be fastened with a minimum of two (2) 5d hot-dipped, galvanized box nails. Fastened $^{3}/_{4}$ in. to 1 in. from the edge of the shingle, and 1$^{1}/_{2}$ in. to 2 in. above the butt line of the next course. In all cases, fasteners shall be of sufficient length to penetrate through the plywood panel or wood plank decking not less than $^{3}/_{16}$ in., or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in. Nails shall be driven straight and flush. Nails shall not be overdriven (see Detail C).

4.10 Hip and ridges may be installed from pre-manufactured units or field assembled units from manufacturer's shingles. The exposed juncture of the roof hip and ridge areas shall be covered with a minimum 6 in. wide strip of ASTM D 226 Type II organic felt, prior to installing the hip and ridge units. No felt shall be left exposed. Lay alternate overlapping hip and ridge units, starting with a double starter course. Each side of the hip and ridge units shall be a minimum of 4 in. wide. Each hip and ridge unit shall be fastened to the roof with two fasteners of the same type as that used for the field shingles. Fasteners shall be of sufficient length to penetrate the plywood panel or wood plank decking not less than $^{3}/_{16}$ in.; or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in. Nails shall be driven straight and flush. Nails shall not be overdriven (see Detail C).

4.11 Metal flashing materials shall comply with Section 1517.6 of the *Florida Building Code, Building*. Metal step flashing shall be used at all vertical side walls. The length of the step flashing units shall be 3 in. longer than the exposure of the shingles. The step-flashing unit shall be installed just up slope from the exposed area of the wood shingle, in such a manner as to be covered by the next wood shingle, while maintaining a minimum 3 in. headlap. Step flashing metal shall extend 5 in. up the vertical surface and 5 in. horizontally onto the wood shingle. Nail each step-flashing unit near the upper corner. Location of the shingle fasteners must be adjusted to insure that the step flashing is not penetrated. Vertical head walls shall be flashed with apron type metal flashing. Wood shingles shall be installed up to the vertical head wall and out over the top course of wood shingles a minimum of 5 in. Wall treatment or flashing or head wall flashing a minimum of 3 in. and shall terminate a minimum of 1 in. above the surface of the wood shingles. Metal counter flashing shall be installed in compliance with Roofing Application Standard RAS 111.

4.12 Roof penetration that protrude through a roof shall be flashed at all intersecting angles to prevent leakage. Flashing details shall be in compliance with manufacturer's recommendations, unless otherwise indicated in roof assembly's Product Approval.

5. Wood Shakes

5.1 Underlayments:

Solid Sheathing: Two plies of ASTM D 226, Type I felt overlapped 19 in., or a single layer of ASTM D 226 Type II felt overlapped a minimum of 4 in. on side laps and 6 in. on the end laps. Fasten with corrosion resistant 12 ga. roofing nails through tin caps. Fasten with two staggered rows in the field of the sheet with a maximum fastener spacing of 12 in. o.c., and one row at the laps fastened 6 in. o.c.

Spaced Sheathing: Underlayment shall be installed at a minimum of 36 in. wide at the eave line, and shall be a minimum of two plies of ASTM D 226, Type I felt overlapped 19 in., or a single layer of ASTM D 226 Type II felt overlapped a minimum of 4 in. on side laps and 6 in. on the end laps. Fasten with corrosion resistant 12 ga. roofing nails through tin caps. Fasten with two staggered rows in the field of the sheet with a maximum fastener spacing of 12 in. o.c. and one row at the laps, fastened 6 in. o.c., at a minimum of 36 in. from the eave of the roof.

Roofing nails shall be of sufficient length to penetrate through the plywood panel or wood plank decking not less than $^3/_{16}$ in., or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in.

5.2 Interlayment shall be a minimum of ASTM D 226 Type I felt with a minimum width of 18 in. and shall be applied between each succeeding course of shakes. Interlayment shall be fastened on the upper edge of the sheet. The bottom edge of the interlayment shall be positioned above the butt edge of each course of shakes, a distance equal to twice the weather exposure of the wood shakes. Extend interlayment up vertical surfaces a minimum of 4 in. No felt shall be exposed.

5.3 Edge metal shall comply with Section 1517.6 of the *Florida Building Code, Building* and RAS 111.

5.4 Valleys may be installed open or closed. A 36 in. wide sheet of minimum ASTM D 226 Type II organic felt shall be installed over the underlayment and centered in the valley, fastened 6 in. o.c. through tin-caps at each edge of the sheet. Minimum end laps shall be 12 in. and fully adhered with approved flashing cement.

5.5 Valley metals shall comply with the Section 1517.6 of the *Florida Building Code, Building*. Valley metal shall be preformed with side returns and a minimum 1 in. high center water diverter. Valley metal shall have a minimum formed width of 20 in. Valley metal shall be fastened with minimum 2 in. wide metal clips spaced 12 in. o.c. Metal clips shall be fabricated of similar metal and fastened with minimum two approved $1^1/_4$ in. annular ring shank roofing nails at every clip (see Detail A).

5.6 Metal laps shall be a minimum of 12 in., and shall be sealed with approved flashing cement. For open valley installations, the wood shakes are to be cut to form a straight edge. The open area of the valley shall be no less than 4 in. and no more than 8 in. wide. For closed valley installations, the wood shakes are to be miter cut along the center water diverter. Wood shake fasteners shall be kept back at least 8 in. from the valley centerline. Wider wood shakes and the positioning of the fasteners higher at the valley may be required.

5.7 The maximum exposure to the weather for wood shakes shall comply with Table 1 herein. An interlayment sheet shall be installed between each shake. The beginning or starter course of wood shakes at the eave line shall be doubled as a minimum. The wood shakes shall project a minimum $^3/_4$ in. to a maximum 2 in. beyond the drip edge at both eaves and rakes.

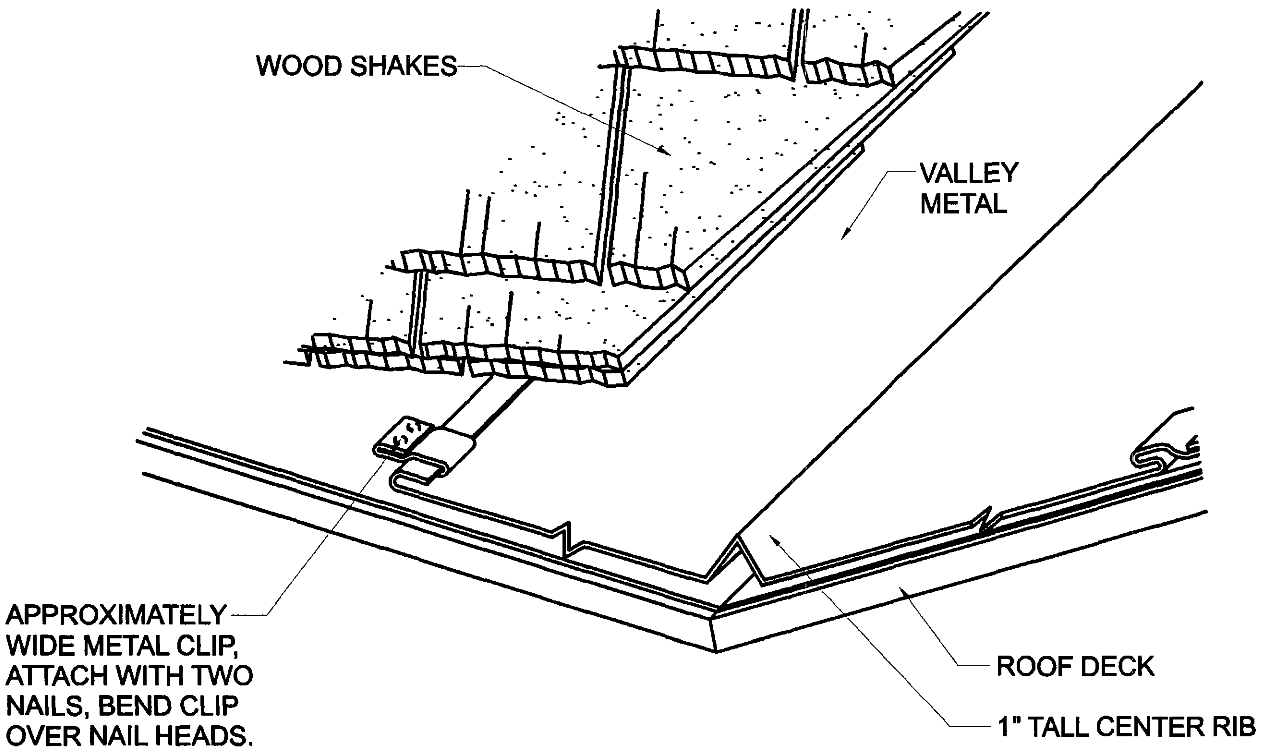
5.8 Spacing between shakes (joints or key ways) shall be a minimum $^1/_4$ in. and a maximum of $^5/_8$ in. Shakes shall be positioned so that they cover the joints in the preceding course. Adjacent courses shall be offset a minimum of $1^1/_2$ in. In any three courses (adjacent), no two joints should be directly aligned (see Detail D).

5.9 Each shake shall be fastened with a minimum of two (2) 6d hot-dipped, galvanized box nails. Fastened $^3/_4$ in. to 1 in. from the edge of the shake, and $1^1/_2$ in. to 2 in. above the butt line of the next course. In all cases, fasteners shall be of sufficient length to penetrate through the plywood panel or wood plank decking not less than $^3/_{16}$ in., or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in.. Nails shall be driven straight and flush. Nails shall not be overdriven (see Detail C).

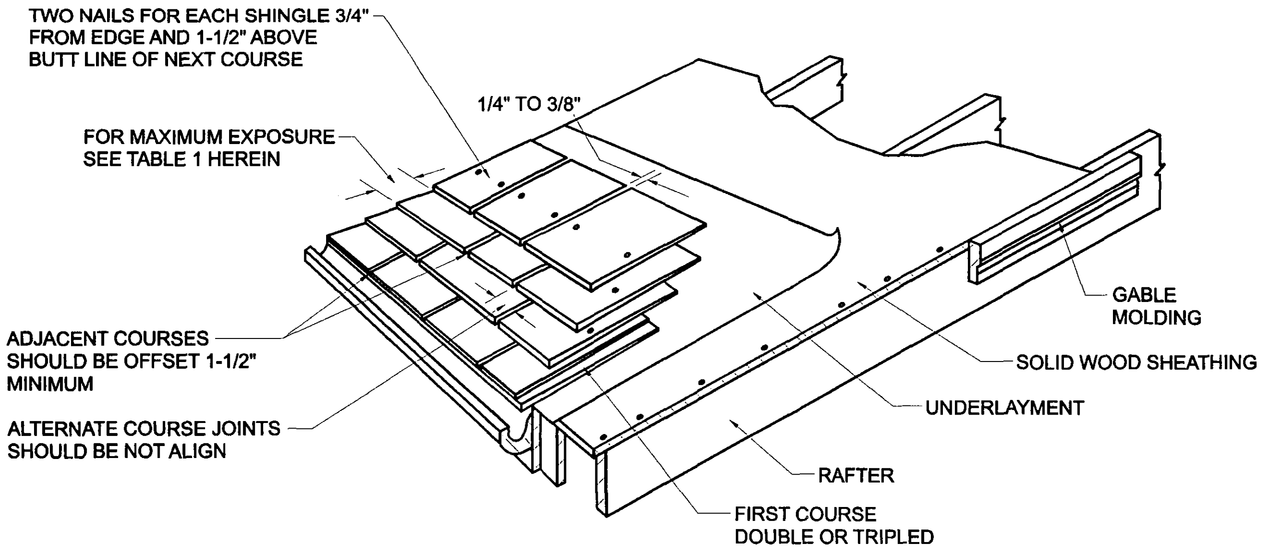
5.10 Hip and ridges may be installed from pre-manufactured units or field assembled units from manufacturer's shakes. The exposed juncture of the roof hip and ridge areas shall be covered with a minimum 6 in. wide strip of ASTM D 226 Type II organic felt, prior to installing the hip and ridge units. No felt shall be left exposed. Lay alternate overlapping hip and ridge units, starting with a double starter course. Each side of the hip and ridge units shall be a minimum of 4 in. wide. Each hip and ridge unit shall be fastened to the roof with two fasteners of the same type as that used for the field shakes. Fasteners shall be of sufficient length to penetrate the plywood panel or wood plank decking not less than $^3/_{16}$ in.; or to penetrate into a 1 in., or greater, thickness of lumber not less than 1 in. Nails shall be driven straight and flush. Nails shall not be overdriven. (see Detail C).

5.11 Metal flashing materials shall comply with Section 1517.6 of the *Florida Building Code, Building*. Metal step flashing shall be used at all vertical side walls. The length of the step flashing units shall be 3 in. longer than the exposure of the shakes. The step-flashing unit shall be installed just up slope from the exposed area of the wood shake, in such a manner as to be covered by the next wood shake while maintaining a minimum 3 in. headlap. Step flashing metal shall extend 5 in. up the vertical surface and 5 in. horizontally onto the wood shake. Nail each step-flashing unit near the upper corner. Location of the shake fasteners must be adjusted to insure that the step flashing is not penetrated. Vertical head walls shall be flashed with apron type metal flashing. Wood shake shall be installed up to the vertical head wall. The head wall flashing shall then be installed to extend up the vertical surface 5 in., and out over the top course of wood shake a minimum of 5 in. Wall treatment or metal counterflashing shall be brought down over all vertical flanges of the step flashing or head wall flashing a minimum of 3 in. and shall terminate a minimum of 1 in. above the surface of the wood shake. Metal counterflashing shall be installed in compliance with RAS 111.

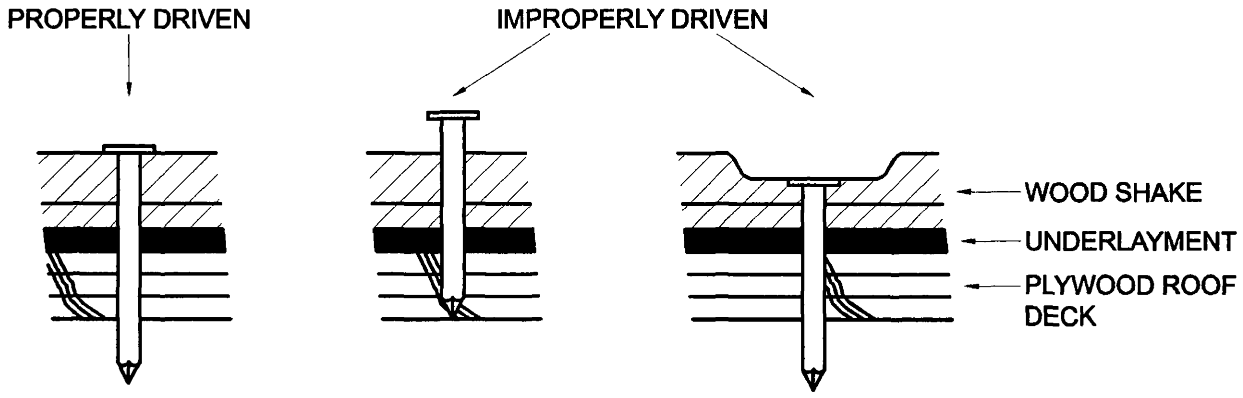
5.12 Roof penetrations that protrude through a roof shall be flashed at all intersecting angles to prevent leakage. Flashing details shall be in compliance with manufacturer's recommendations, unless otherwise indicated in roof assembly's Product Approval.


WOOD SHAKES
VALLEY METAL
APPROXIMATELY WIDE METAL CLIP, ATTACH WITH TWO NAILS, BEND CLIP OVER NAIL HEADS.
ROOF DECK
1" TALL CENTER RIB

DETAIL A


TWO NAILS FOR EACH SHINGLE 3/4" FROM EDGE AND 1-1/2" ABOVE BUTT LINE OF NEXT COURSE
1/4" TO 3/8"
FOR MAXIMUM EXPOSURE SEE TABLE 1 HEREIN
GABLE MOLDING
SOLID WOOD SHEATHING
ADJACENT COURSES SHOULD BE OFFSET 1-1/2" MINIMUM
UNDERLAYMENT
ALTERNATE COURSE JOINTS SHOULD BE NOT ALIGN
RAFTER
FIRST COURSE DOUBLE OR TRIPLED

DETAIL B

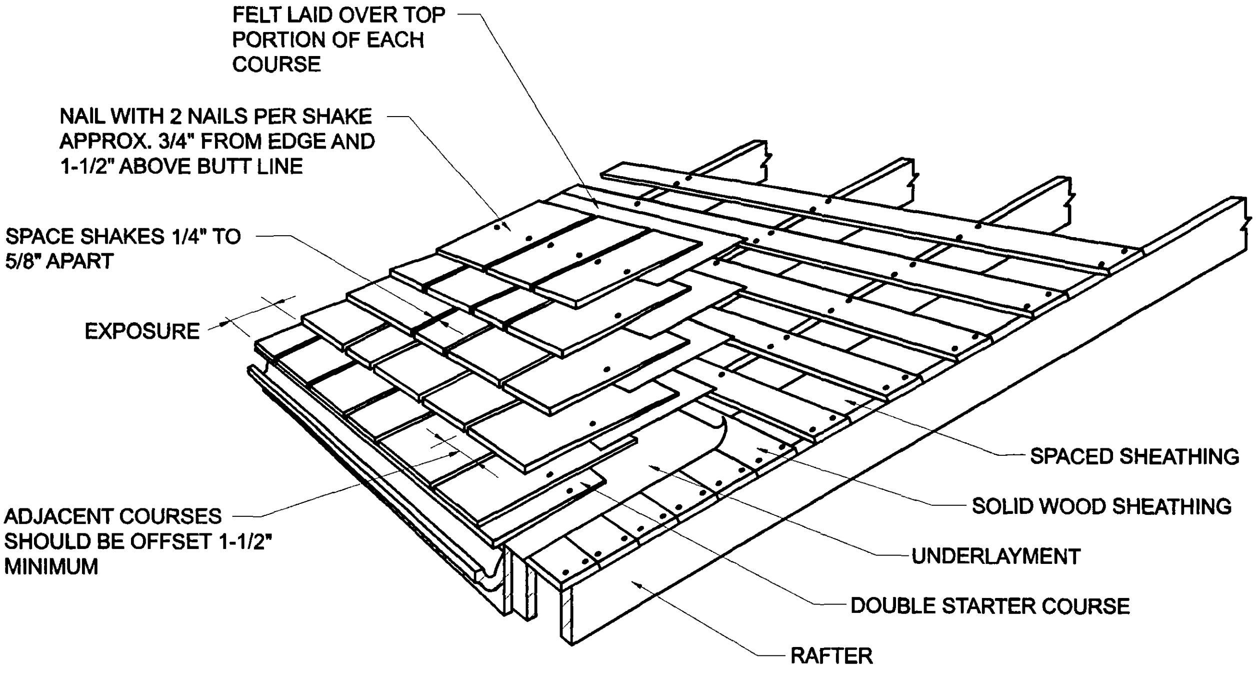


DRIVEN STRAIGHT, GOOD PENETRATION, AND HEAD BEARS FIRMLY AGAINST THE WOOD SURFACE

UNDERDRIVEN, INADEQUATE DECK PENETRATION.

OVERDRIVEN, CUTS INTO SHAKE AND DAMAGES WOOD

DETAIL C


FELT LAID OVER TOP PORTION OF EACH COURSE
NAIL WITH 2 NAILS PER SHAKE APPROX. 3/4" FROM EDGE AND 1-1/2" ABOVE BUTT LINE
SPACE SHAKES 1/4" TO 5/8" APART
EXPOSURE
ADJACENT COURSES SHOULD BE OFFSET 1-1/2" MINIMUM
SPACED SHEATHING
SOLID WOOD SHEATHING
UNDERLAYMENT
DOUBLE STARTER COURSE
RAFTER

DETAIL D

ROOFING APPLICATION STANDARD (RAS) No. 133

STANDARD PROCEDURE FOR INSTALLATION OF METAL ROOF SYSTEMS

1. Scope

1.1 This application standard has been developed to provide consistent information for the installation and uses of metal roof systems.

1.2 This application standard determines the options for specific flashing conditions and provides guidelines for application in compliance with Product Approval.

1.3 This application standard describes various flashing methods that can be used to terminate metal roof assemblies.

2. Definitions

2.1 For definitions of terms used in this application standard, refer to ASTM D 1079; and the *Florida Building Code, Building.*

3. General Requirements

3.1 All perimeter flashings shall meet the material sizing and attachment requirements set forth RAS 111.

3.2 Underlayment shall be in accordance with Chapter 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

4. Specific Metal Roof System Assembly Types and Related Requirements

4.1 Metal roofing panels shall comply with the minimum test requirements set forth below:

Accelerated Testing of Coating	ASTM G 23 (2000 hours)
Salt Spray Testing of Coating	ASTM B 117 (1000 hours)

4.2 Roof System Assemblies utilizing concealed clips shall be installed with clips of the size, material, gage and markings specified in the metal roofing Product Approval. No substitutions shall be allowed.

4.3 Sealants, closure strip and accessory components shall be as specified in the metal roofing Product Approval.

5. Design Considerations

5.1 Metal panel continuous lengths shall not exceed 45 feet for steel and stainless steel and 32 feet for aluminum, copper and monel.

5.2 Clips, cleats and/or fastening points shall be as detailed in the metal roofing Product Approval. All field fabricated cleats shall have two approved nails or fasteners in each, protected by a foldover tab (see Figure 1, below). Cleats shall be fabricated from materials listed in the metal roofing Product Approval.

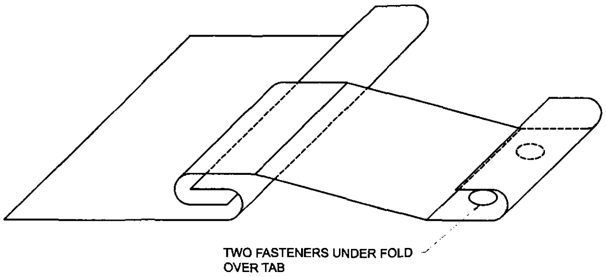


FIGURE 1
EXAMPLE OF PANEL CLEAT

5.3 All components shall be of compatible material.

5.4 Maximum design pressures listed in the metal roofing Product Approval shall meet or exceed design pressures for the field area of the roof determined in compliance with the *Florida Building Code, Building*. Design pressures for perimeter and corner areas may be increased through data extrapolation.

5.4.1 All extrapolation of data shall be signed and sealed by a registered architect or a professional engineer must be submitted with the uniform roofing permit application.

5.5 Woodblocking

5.5.1 All woodblocking installed to secure or support metal roofing panels shall be in compliance with the American Wood Preservers Association salt pressure treating specification C-2 or C-9.

5.5.2 All woodblocking shall be secured to the substrate in compliance with RAS 111.

6. Sealants and Closure Strips

6.1 Closure strip shall be cut or fabricated to snugly fit the metal profile creating an efficient seal. Closure strip shall be bonded in place with a continuous bead of approved sealant, top and bottom, to eliminate movement or the potential of dislodging. Joints in the closure strip shall be tight.

7. Perimeters

7.1 Eaves may be terminated with a drip edge flashing (see Figure 4) or a gutter at the transition with a side wall. Refer to material and application methods for fabrication, attachment, and sizing set forth in RAS 111.

7.2 Metal profiles shall be closed at eave conditions with closure strip, sealant or metal caps to create a watertight closure.

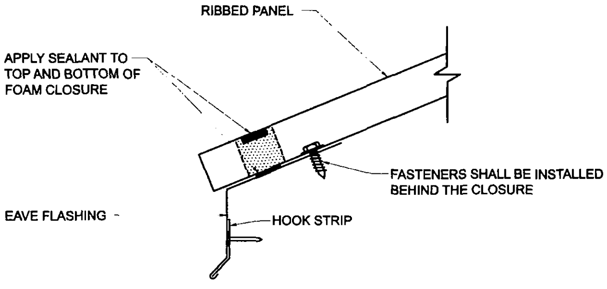

RIBBED PANEL
APPLY SEALANT TO TOP AND BOTTOM OF FOAM CLOSURE
FASTENERS SHALL BE INSTALLED BEHIND THE CLOSURE
EAVE FLASHING
HOOK STRIP

FIGURE 2
TYPICAL EAVE TERMINATION DETAIL WITH CLOSURE STRIP

7.3 Rake and Rake Wall

7.3.1 Rake wall flashings are base flashings where a metal Roof System Assembly abuts a vertical wall at a slope condition (see Figure 3). The flashing shall provide a waterproofing bridge between the metal Roof System Assembly and the vertical wall.

7.3.1(a) Rake wall flashings shall terminate at the high point of the panel or a transition joint shall be formed to avoid waterflow at the metal transition.

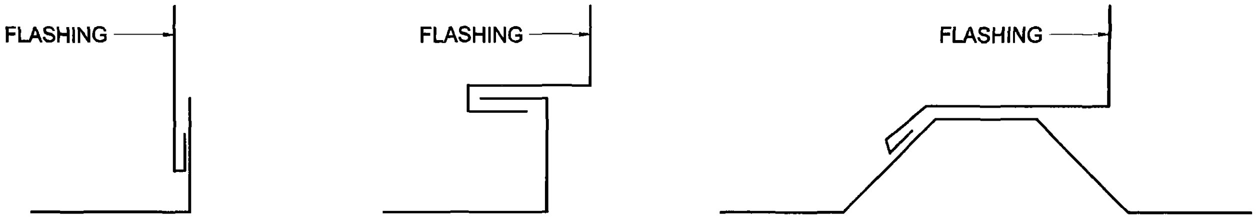


FIGURE 3
TYPICAL PROFILES OF RAKE WALL FLASHINGS

7.3.2 Rake flashings are perimeter flashings at the sloping edge of the metal Roof System Assembly, usually terminated with a drip edge or gravel stop flashing (see Figure 4, below). Rake flashings shall be fabricated from materials, sized and attached in compliance with RAS 111.

7.3.2(a) Rake flashings shall terminate at the high point of the panel as detailed in 7.3.1(a).

7.4 Ridge, hip and headwall flashings shall be formed of metal in combination with woodblocking, metal or closure strip material and fastening devices.

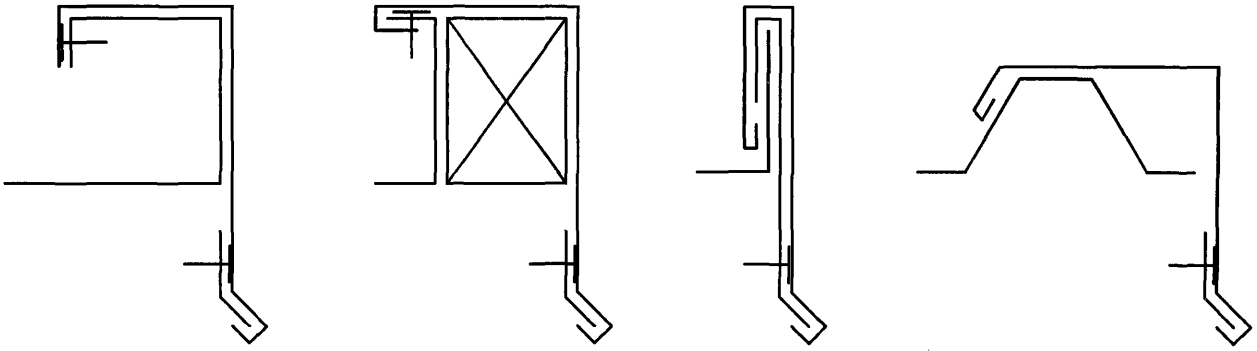


FIGURE 4
TYPICAL RAKE PROFILES

7.4.1 All panels shall be turned up at terminations to create a water stop. If the metal profile is too rigid or the vertical metal will not allow for a bend, the pans shall be notched and turned up with sealant applied at all cuts and openings.

7.4.2 All end panels shall be closed with a metal roof pan closure strip or a closure strip bonded into place. (see Section 8.9, herein).

7.4.3 End and ridge closures shall be designed to resist water blow back as well as vermin and insect entry.

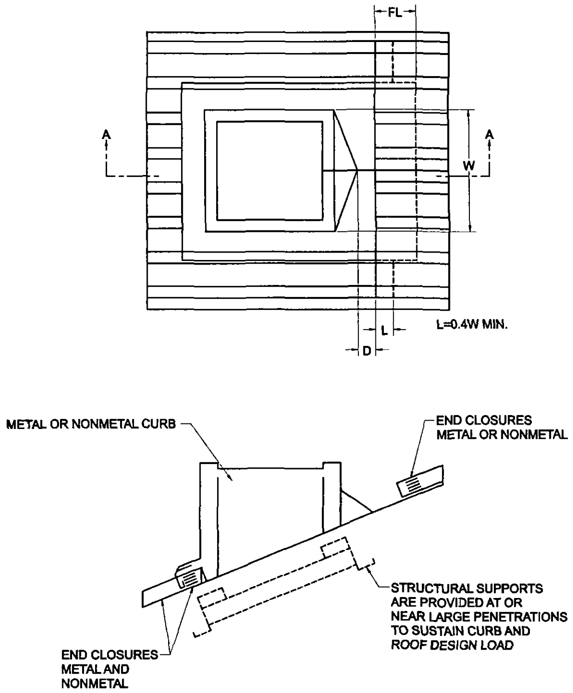
8. Penetrations

8.1 All metal overlaps shall be formed to shed water. Laps of rectangular shaped penetration flashings over panels (for lower elevations) or under panels (for higher elevations) shall be a minimum of 12 in. and shall have a continuous double row of approved sealant applied.

8.1.1 Side laps at the edge of base panels shall occur on ribs or seams and shall be sealed with a continuous double row of approved sealant.

8.1.2 Drainage clearance troughs shall be provided between a rectangular penetration flashing and the ends of interrupted ribs at the high side of the flashing. When the width of the rectangular flashing exceeds 18", or is greater than one pan width of the roof panel, a cricket shall be installed to direct water flow away from the penetration. (See Figure 6, below.)

8.2 Penetration flashings shall be designed to move with the metal roof panels during periods of expansion and contraction. The metal roofing system, in conjunction with the penetration flashings, must move without causing failure of the transition joints. (see Figures 7 and 8, below).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A
A
W
L
D
L=0.4W MIN.
METAL OR NONMETAL CURB
END CLOSURES METAL OR NONMETAL
STRUCTURAL SUPPORTS ARE PROVIDED AT OR NEAR LARGE PENETRATIONS TO SUSTAIN CURB AND ROOF DESIGN LOAD
END CLOSURES METAL AND NONMETAL

FIGURE 6
TYPICAL CURB FLASHING

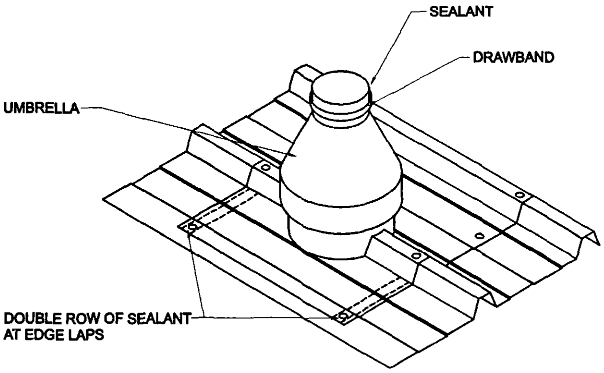


FIGURE 7A
PENETRATION FLASHING

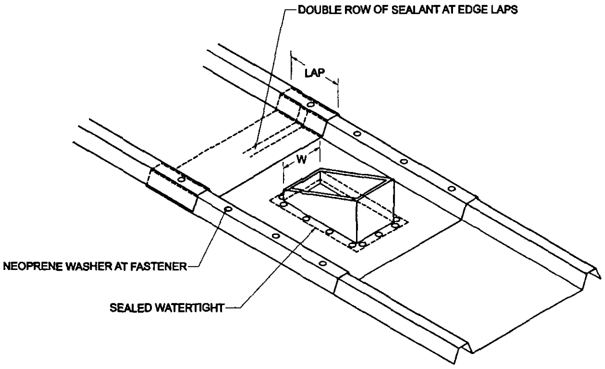

DOUBLE ROW OF SEALANT AT EDGE LAPS
LAP
W
NEOPRENE WASHER AT FASTENER
SEALED WATERTIGHT

FIGURE 7B
PENETRATION FLASHING

9. Transitions

9.1 Valley Flashings

9.1.1 Valley flashings shall be fabricated from materials that are the same or are compatible with the roof panel system, and not less than the gage of the metal panel. Valleys must be supported by underlying decking (for nonstructural systems) or by structural members running the length of the valley (for structural systems).

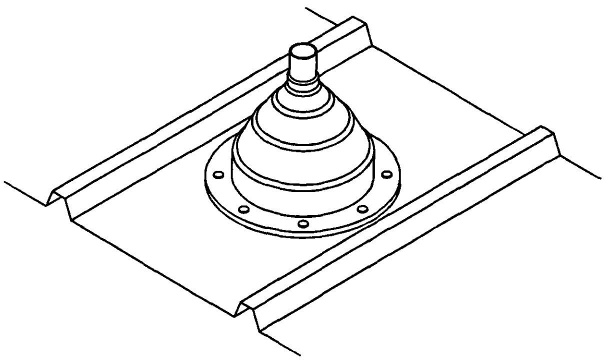


FIGURE 8
ELASTOMERIC FLASHING

9.1.2 Panels shall be secured at the valley by:

9.1.2(a) a hold down cleat at the transition with the valley (see Figure 9, above); or

9.1.2(b) fasteners penetrating through the panel to the structural members or sheeting below; or

9.1.2(c) other method defined in the Product Approval for the metal Roof System Assembly.

9.1.3 Cleated panels are required for concealed fastener systems such as standing seam.

9.1.3(a) The cleats shall be set in a bead of sealant and fastened 6 in. o.c. with a pan head screw on prefinished metals. Alternatively, cleats may be soldered in place when using corrosion resistant metals.

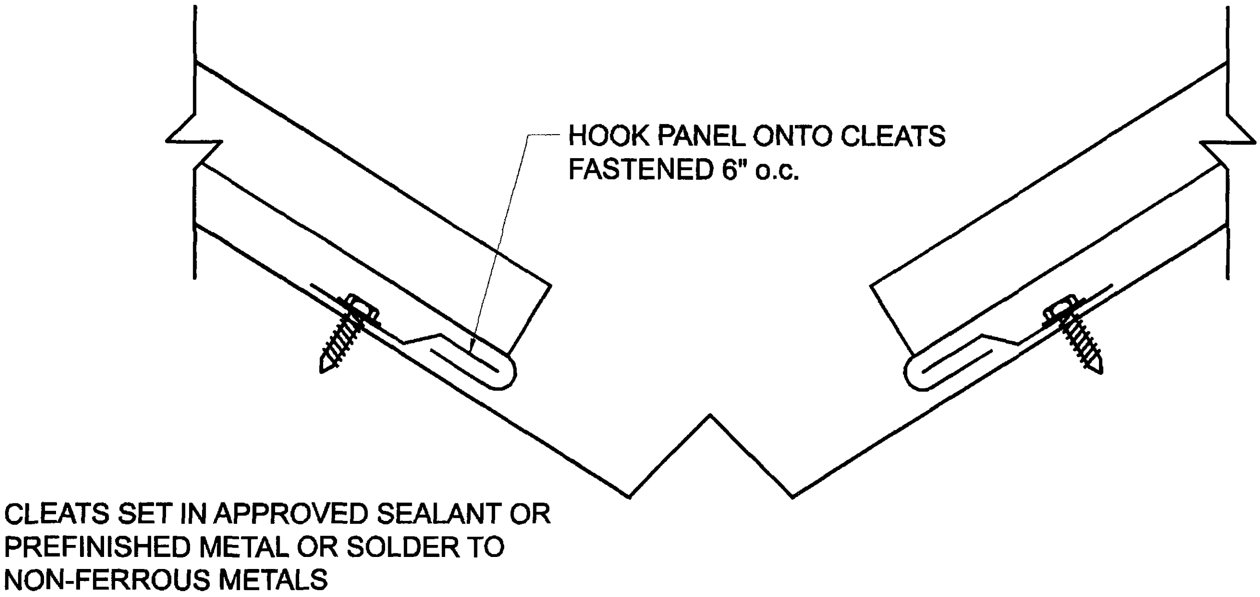

HOOK PANEL ONTO CLEATS FASTENED 6" o.c.
CLEATS SET IN APPROVED SEALANT OR PREFINISHED METAL OR SOLDER TO NON-FERROUS METALS

FIGURE 9
RECOMMENDED STANDING SEAM VALLEY

9.1.4 Mechanically fastened panels shall be secured at the valley transition (see Figure 10.)

9.1.5 Panels shall lap a minimum of 3 in. over the valley while maintaining a minimum 6 in. drainage channel.

9.1.6 All valley flashing endlaps shall be a minimum of 6 in. and shall be mechanically fastened and sealed.

9.2 Details shown in the *Architectural Sheet Metal Manual*, as published by SMACNA, as adopted by the *Florida Building Code, Building* are acceptable.

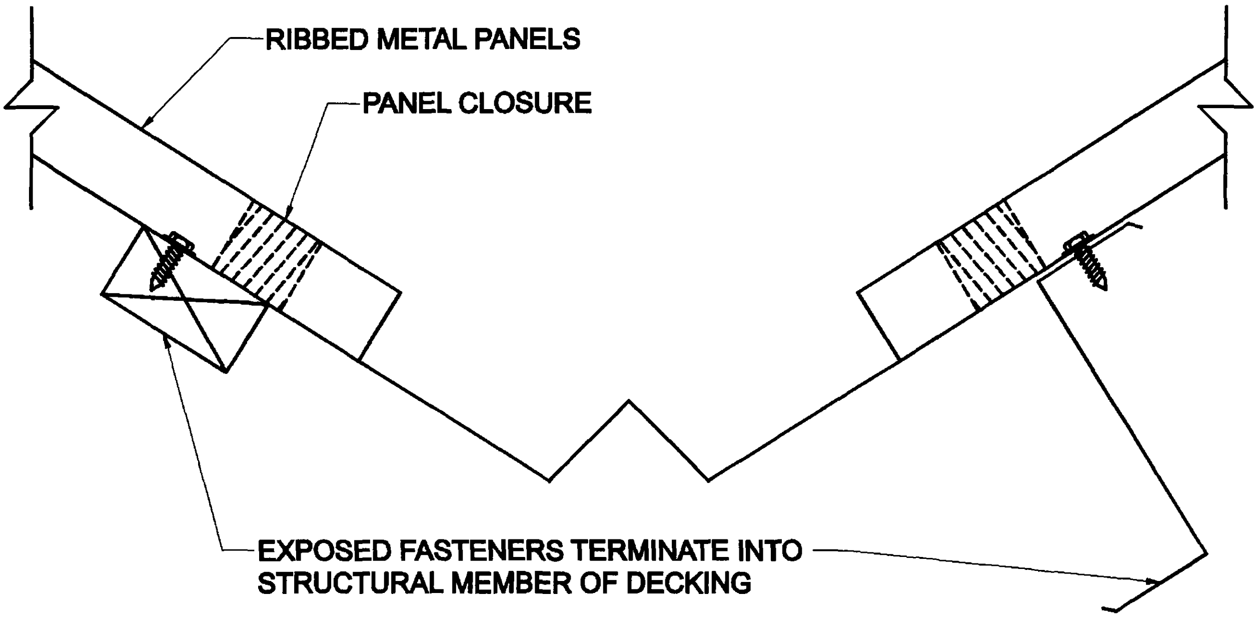

RIBBED METAL PANELS
PANEL CLOSURE
EXPOSED FASTENERS TERMINATE INTO STRUCTURAL MEMBER OF DECKING

FIGURE 10
RIBBED PANEL VALLEY

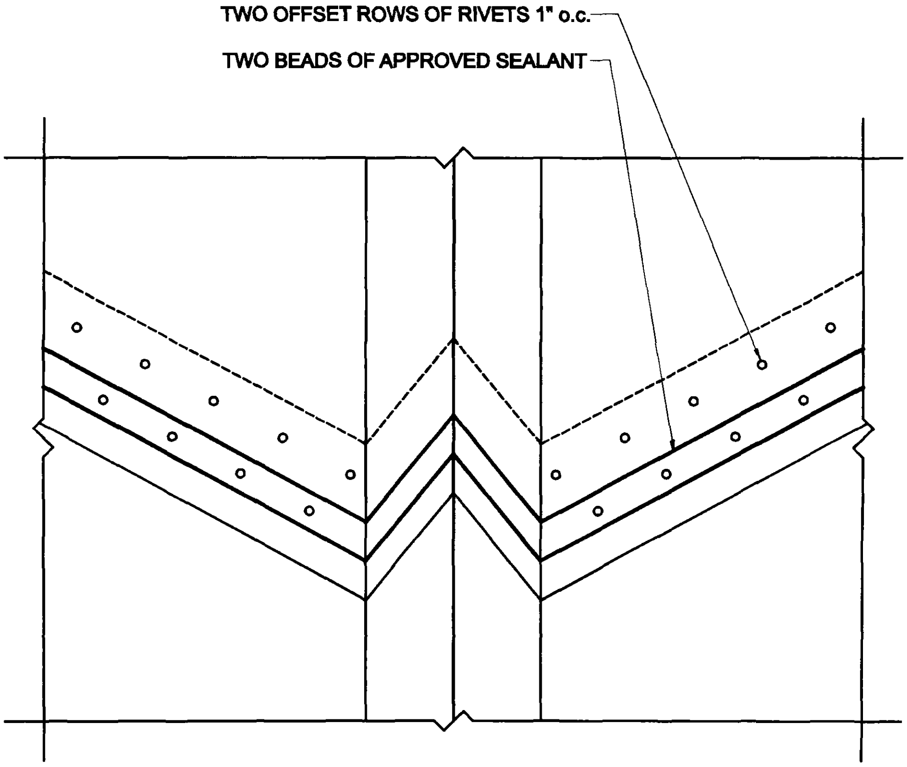

TWO OFFSET ROWS OF RIVETS 1" o.c.
TWO BEADS OF APPROVED SEALANT

FIGURE 11
SEALED LOW SLOPE VALLEY LAP

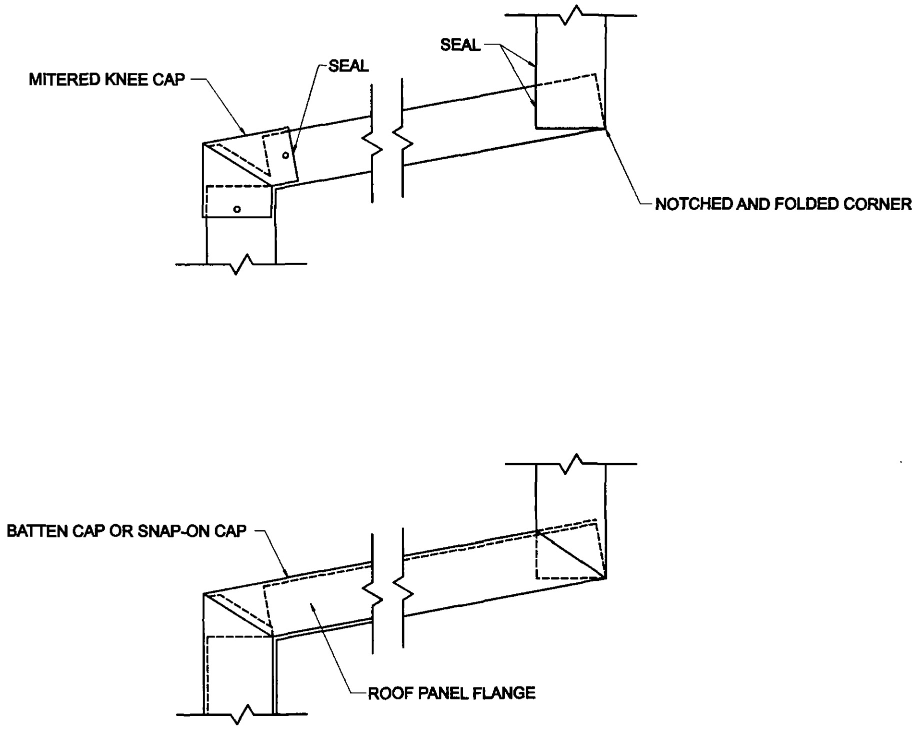


FIGURE 12
TRANSITION WITH KNEE BENDS

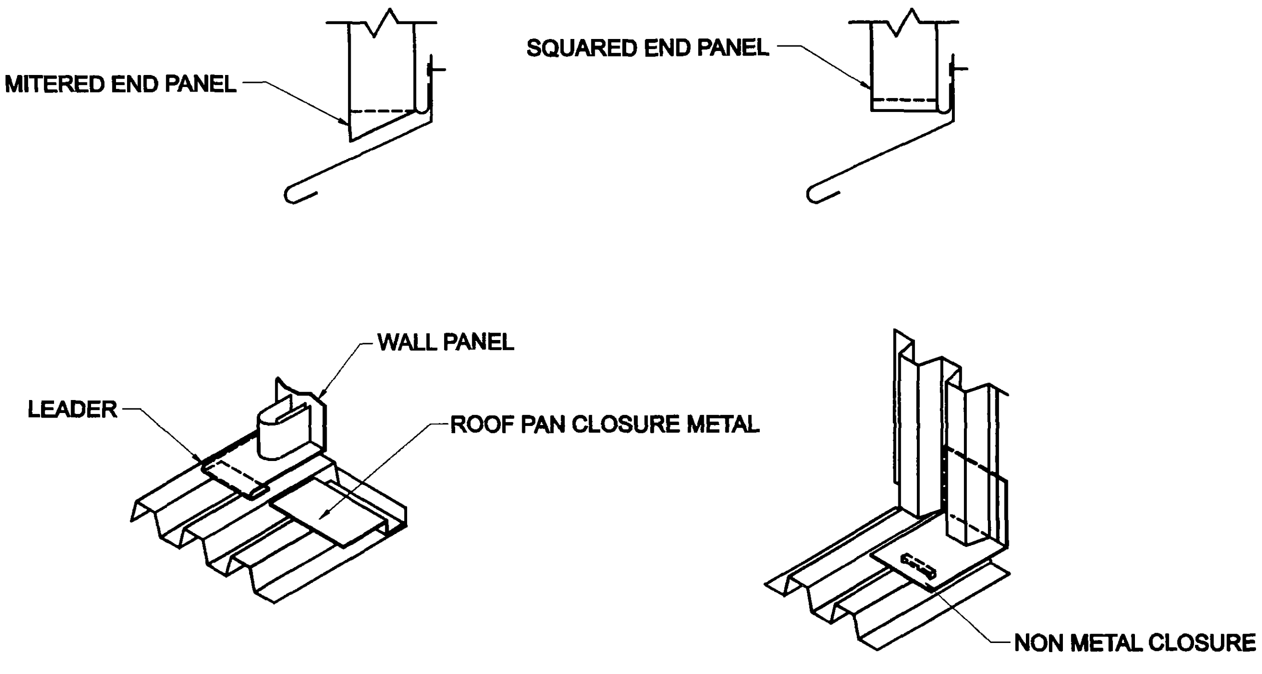


FIGURE 13
TRANSITION FLASHINGS AT HEADWALL CONDITION

ROOFING APPLICATION STANDARD (RAS) No. 137

STANDARD REQUIREMENTS FOR MECHANICAL ATTACHMENT OF SINGLE-PLY ROOF COVERINGS TO VARIOUS SUBSTRATES

1. Scope

1.1 The standards set forth herein provide a means of determining the mechanical attachment of single-ply roof covers to insulated or uninsulated roof decks in compliance with the requirements set forth in Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*; specifically Section 1619 covering wind loads. For the mechanical attachment or bonding of insulation panels, refer to RAS 117.

1.2 All testing shall be conducted by an approved testing agency. A Professional Engineer, Registered Architect, or Registered Roof Consultant shall sign all calculations.

2. Definitions

2.1 For definitions of terms used in this application standard, refer to ASTM D 1079 and the *Florida Building Code, Building*.

3. General

3.1 All single-ply roof covering fasteners, stress plates and/or fastener assemblies shall have Product Approval, and shall be listed in the single-ply roof assembly manufacturer's Product Approval.

3.2 All insulation products shall have Product Approval, and shall be listed in the single-ply roof assembly Product Approval.

3.3 Care shall be taken not to overdrive single-ply membrane fasteners. Overdriving can deform stress plates and/or tear the membrane, reducing the uplift resistance performance of the Roof System assembly. All damaged stress plates shall be removed and replaced.

3.4 All overdriven fasteners or fasteners driven at an angle, shall be removed and replaced. If the insulation facer has been broken, or membrane torn or punctured by a stress plate, that section of insulation panel or membrane shall be removed and replaced.

3.5 All fasteners shall be installed in compliance with the fastener manufacturer's published installation instructions and the limitations set forth in the Product Approval. Fasteners shall be installed with tooling as specified by the fastener manufacturer.

3.6 In steel deck applications membrane attachment shall be perpendicular to the flutes of the steel deck. Membrane attachment shall be to the top flute of the deck. Fasteners spacing shall not be less, than that of the metal deck flute spacing.

4. Fasteners and Spacing

4.1 All fasteners and stress plates shall be tested in compliance with Chapter 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

4.2 The roofing assembly Product Approval shall list the maximum design pressure for the accepted assembly. Such pressure shall be applicable to the field of the roof area (1) as defined in ASCE 7. Should the roof assembly Product Approval allow extrapolation to perimeter and corners areas [(2) and (3)] as defined in ASCE 7, the following shall apply:

- The maximum extrapolation shall not be greater than 280 percent.
- The minimum fastener separation shall not be less than 6 inches o.c. Should determined fastener density require closer fastener spacing, then the membrane width shall be reduced, (e.g., half sheets).

- If the perimeter and/or corner areas of the roof have calculated design pressures which are less than or equal to the maximum design pressures noted in the roof assembly Product Approval, then specified membrane attachment shall also apply in these areas.

4.3 In recover or reroof applications if testing in compliance with TAS 105 of the membrane fasteners results in a minimum characteristic resistance force less than 275 lbf (1224 N), a Professional Engineer, or Registered Architect shall perform a moisture survey, in compliance with TAS 126, and examine the deck's integrity. The moisture survey and examination results, along with the withdrawal resistance test results and a proposed deck repair/replacement specification, shall be submitted to the building official for review prior to issuance of a roofing permit.

4.3.1 Subsequent to repair or replacement of the deck, a withdrawal resistance test of the fasteners shall be conducted. The same criteria noted above shall apply.

5. Single-Ply Membrane Attachment

5.1 Should the roof assembly Product Approval allow extrapolation to perimeter and corners areas [(2) and (3)] as defined in ASCE 7, the following shall apply:

5.1.1 Single-ply membrane attachment for elevated pressure zones may be determined through extrapolation of the data for field area attachment.

5.1.1.1 Alternatively, the mechanically attached, single-ply roof assembly may be tested for dynamic uplift pressure resistance, in compliance with Appendix B of TAS 114 resulting in a "fastener assembly design value." This "Fastener Assembly Design Value" will be listed in the single-ply roof assembly Product Approval for use in determining fastener spacing.

6. Example of Data Extrapolation

Notes: The following data extrapolation example results in a "Fastener Value" which is based on the maximum design pressure from a particular roof assembly Product Approval. The maximum design pressures are the result of laboratory uplift testing of the assembly after a 2:1 margin of safety is applied. Therefore, the "Fastener Value" determined herein inherently has a 2:1 margin of safety applied.

6.1 Known:

Consider a building having an uninsulated concrete deck and a roof mean height less than 60 feet where the design pressures are as follows:

Field Area:	*- 43.0 psf*
Perimeter Area:	*- 56.0 psf*
Corner Areas:	*- 90.0 psf*

Consider a roof assembly Product Approval which includes a system having a maximum design pressure of -45 psf. The Product Approval specifies a single-ply membrane mechanically attached 18 in. o.c. through 4.5 in. wide fastening tabs spaced 18 in. o.c. on the underside of the membrane.

6.1.1 Determine the number of square feet per fastener (x):

The following equation may be utilized to determine the number of square feet per fastener (x) if this number is unknown.

$$X = \frac{(row\ spacing\ x\ fastener\ spacing)}{144}$$

For this case, this results in 2.25 ft^2 per fastener, as shown below.

$$X = \frac{(18\,in\ x\ 18\,in)}{144} = 2.25\ ft^2$$

6.1.2 Determine the "Fastener Value."

General Equation:

$$f_v = (\max.design\ pressure)\ x\ [square\ feet\ per\ fastener\ (X)]$$

For this case, this results in a fastener value of 101.25 lbf, as shown below.

$$f_v = \left(\frac{45\,lbf}{ft^2}\right) x \left(\frac{2.25\,ft^2}{fastener}\right) = 101.25\,lbf$$

6.1.3 Determine a fastener spacing (FS) to meet the design pressures in the elevated pressure zones of the roof.

General Equation:

$$FS = \frac{f_v x\, 144}{P\ x\ RS}$$

where:
FS = fastener spacing (in);
f_v = fastener value (lbf);
P = design pressure (psf); and,
RS = row spacing (in.)

Perimeter Area:

$$FS = \frac{(101.25)\ x \left(\frac{144\,in^2}{ft^2}\right)}{(56.0\ psf)\ x\ (18\ inches)} = 14.5\ inches$$

All fractions shall be rounded down to the next whole number. Therefore, a fastener spacing of 14 in. o.c. through 4.5 in. wide fastening tabs spaced 18 in. o.c. on the underside of the membrane would be acceptable for the perimeter area.

Corner Area:

$$FS = \frac{(101.25\ x \left(\frac{144\,in^2}{ft^2}\right)}{(90.0\ psf)\ x\ (18\ inches)} = 9.0\ inches$$

Therefore, a fastener spacing of 9 in. o.c. through 4.5 in. wide fastening tabs spaced 18 in. o.c. on the underside of the membrane would be acceptable for the corner areas.

ROOFING APPLICATION STANDARD (RAS) No. 150
PRESCRIPTIVE BUR REQUIREMENTS

1. Scope

1.1 This application standard shall be used where the authority having jurisdiction has adopted its use, and in accordance with the provisions of this code.

2. Definitions

2.1 For definitions of terms used in this application standard, refer to ASTM D 1079 and the *Florida Building Code, Building*.

3. Built-up and Prepared Roof Covering Application

3.0 General

3.1 DECK PREPARATION: Before starting the roof covering:

3.1.1 All roof decks shall be broom-cleaned and dry.

3.1.2 Where practicable, eaves; parapet walls; vertical walls; penthouses and similar structures above the roof level shall have been completed.

3.1.3 Cant strips, where provided, shall extend at least three inches (3 in.) up vertical surfaces.

3.1.4 All eaves shall provide firm, nailable backing for the secure attachment of gravel stops and eave and gable drip.

3.1.5 All precast and prestressed concrete roof components shall be provided with insulation, or other leveling fill, where such component edges are more than one-half inch ($^1/_2$ in.) from being flush.

3.2 ATTACHMENT: All roof coverings shall be attached to the various types of decks by mopped-on adhesives or by mechanical fastening as set forth herein, or by other approved materials or methods.

3.3 ADHESIVES:

3.3.1 Bituminous compounds shall be asphalt (ASTM D 312), coal tar pitch (ASTM D 450), modified bitumen, or cold-applied roofing cement (ASTM D 4586 or ASTM D 3019, Type III).

3.3.2 Hot asphalt shall be applied in a quantity not less than 25 pounds plus or minus 15 percent per roofing square per ply and 60 pounds plus or minus 20 percent per square for flood coats and at a temperature recommended by the manufacturer for the system being installed. However, kettle or tanker temperatures should not exceed the following:

Type I Asphalt:	475 °F
Type III & IV Asphalt:	525 °F

NOTE : Asphalt can be heated to within 25 °F below the actual flash point, but this temperature limitation should never be exceeded.

3.3.3 Coal tar pitch shall be applied in a quantity not less than 25 pounds plus or minus 15 percent per roofing square per ply and 70 pounds plus or minus 20 percent per square for flood coats and at a temperature of not less than 275 nor more than 350 °F (350 to 400 °F in the kettle).

3.3.4 Where roof incline exceeds two inches (2 in.) per foot, bituminous compounds shall be steep asphalt Type III or Type IV.

NOTE : Coal tar pitch not to exceed a slope of one-half inch ($^1/_2$ in.) per foot with organic felts, if using glass felts or tar coated felts, slope not to exceed one-quarter inch ($^1/_4$ in.) per foot.

3.3.5 Adhesive compounds other than bitumen may be applied subject to manufacturer's specifications.

4. BUILT-UP ROOF COVERING:

4.1 Materials: All materials used in the assembly of fire-retardant and ordinary built-up coverings shall bear the label of the Underwriter's Laboratories, Inc., and be compatible with Class A, Class B, or Class C roofing. Material shall be delivered in original packaging bearing the manufacturer's labels.

4.2 ANCHOR SHEET: The anchor sheet, as defined herein, shall be a minimum one #30 felt lapped two inches (2 in.) and turned up vertical surfaces a minimum of four inches (4 in.) and secured as set forth herein.

4.3 WOOD DECKS:

4.3.1 Fasteners securing the anchor sheet to nominal one inch (1 in.) lumber or to wood based structural-use panels three-quarters inch ($^3/_4$ in.) or more in thickness shall be noncorrosive smooth shank nails with a shank diameter of a minimum of 0.118 inches or 11 gage, heads not less than three-eighths inches ($^3/_8$ in.) (0.375) diameter and not less than one inch (1 in.) in length; or non-corrosive 12 gage wire ring-shanked nails having

TABLE 1 (3)		
FOR MINIMUM BASE SHEET (5) **1 LAYER, TYPE #30, ASTM D 226 - TYPE II**		
Mean Roof	Fastening Pattern (1)	
Height (Ft.)	Perimeter Edge (2)	Field (4)
0-30	6 in. @ laps, 2 rows @ 6 in. midsheet	6 in. @ laps, 2 rows @ 12 in. midsheet
40	6 in. @ laps, 2 rows @ 6 in. midsheet	6 in. @ laps, 2 rows @ 9 in. midsheet
FOR MINIMUM BASE SHEET (6) **1 LAYER, TYPE #43, ASTM D 2626 - TYPE 1**		
Mean Roof	Fastening Pattern (1)	
Height (Ft.)	Perimeter Edge (2)	Field (4)
0-30	12 in. @ laps, 2 rows @ 15 in. midsheet	12 in. @ laps, 2 rows @ 18 in. midsheet
40	12 in. @ laps, 2 rows @ 12 in. midsheet	12 in. @ laps, 2 rows @ 18 in. midsheet

FOOTNOTES:

(1) See section 4 for fasteners.

(2) Perimeter edge is measured from all roof edges and each side of ridge as follows:
The smaller of 0.10 x minimum building width or 0.40 x mean roof height, gut not less than 0.04 x minimum building width or 3 feet.

(3) This table applies to roof slopes up to three inches (3 in.) per twelve inches (12 in.) (Maximum)

(4) Rows of fasteners, midsheet, shall be evenly spaced across width of sheet and staggered along length of sheet.

(5) Patterns shown require a minimum withdrawal capacity of 34 lb per fastener (unfactored.)

(6) Patterns shown require a minimum withdrawal capacity of 67 lb per fastener (unfactored.)

not less than 20 rings per inch, not less than one inch (1 in.) in length with heads not less than three-eighths inch ($^3/_8$ in.) in diameter.

4.3.2 Fasteners securing the anchor sheet to wood based structural-use panels less than three-quarters inch ($^3/_4$ in.) in thickness shall be non corrosive smooth shank nails with a shank diameter of a minimum of 0.118 inches or eleven (11) gage, heads not less than three-eighths inch ($^3/_8$ in.) (0.375 in.) diameter and not less in length than will penetrate such wood based structural-use panels plus three-sixteenths inch ($^3/_{16}$ in.); or noncorrosive 12 gage wire ring-shanked nails having not less than 20 rings per inch, heads not less than three-eighths inch ($^3/_8$ in.) diameter and not less in length than will penetrate such wood based structural-use panels plus three-sixteenths inch ($^3/_{16}$ in.).

4.3.3 Such fasteners shall be applied through tin-caps not less than one and five-eighths inches ($1^5/_8$ in.) nor more than two inches (2 in.) in diameter and of not less than 32-gage sheet metal.

4.3.4 Spacing of such fasteners along the laps of sheets and both ways in the field between laps shall comply with Table 1, based upon height above grade.

4.3.5 Where the architectural appearance is to be preserved from below, anchor sheet shall be secured in accordance with Section 1519.5.2

4.3.6 Other sub-deck systems may use the spacing shown in Table 1 provided each fastener has the required withdrawal load in the particular substrate for which the fastener is designed.

4.3.7 Sheathing paper shall be applied on such decks where anchor sheets are pitch-tarred felts only and shall not be required under asphalt felts.

4.4 OTHER NAILABLE DECKS: Poured gypsum, precast gypsum planks, poured Vermiculite and Perlite (light-weight, insulating concrete), as well as foamed cellular concrete and structural wood-fiber used as roof decking are considered nailable and anchor sheets shall be attached as follows:

4.4.1 Poured gypsum and pre-cast gypsum planks: Use mechanical fasteners providing equal withdrawal resistance when spaced as set forth in Table 1 of this Code.

4.4.2 Poured Vermiculite, Perlite, foamed cellular concrete, and other light-weight, insulating concrete: Use only mechanical fasteners providing resistance to uplift not less than those shown in Table 1.

4.4.3 Structural wood fiber units: Use mechanical fasteners specified by the deck manufacturer, or after all joints have been stripped with six inch (6 in.) wide felt applied with approved cold adhesive, the anchor sheet may be solid mopped to such decks.

4.5 NON-NAILABLE DECKS: Poured concrete and precast deck units are considered non-nailable and anchor sheets shall be fastened as follows:

4.5.1 Such decks shall be primed with asphalt primer applied at the rate of one and one third ($1\,^1/_3$) gallons per roofing square, solidly on poured decks but held back four inches (4 in.) from precast unit joints.

4.5.2 Strip or solid mop, holding back four inches (4 in.) from precast unit joints, using dead level asphalt or coal tar pitch as the adhesive unless otherwise specified on the plans and permit and embed anchor sheet firmly in the hot bitumen lapping each sheet four inches (4 in.).

4.5.3 Where the incline of such decks exceeds three inches (3 in.) per foot, anchor sheets shall, in addition to mopping, be mechanically fastened to wood strips spaced not more than 24 inches apart, cast into such decks.

4.5.4 Such wood strips shall be not less than a nominal one by two inches (1 in. x 2 in.), pressure treated with approved preservative, chamfered or otherwise secured flush with the deck surface.

4.5.5 Anchor sheets shall be attached to such wood strips with three-quarter inch ($^3/_4$ in.) long fasteners applied through tin caps and spaced as set forth herein.

4.5.6 Anchor sheet attachment shall satisfy the resistance to uplift requirements of Section 4.3.6 herein.

4.6 METAL DECKS: Metal decks shall be covered with mechanically fastened roof insulation.

4.7 OTHER DECKS: Attachment of the anchor sheet to decks other than those specifically provided for herein shall be as approved by the building official.

4.8 ADDITIONAL SHEETS:

4.8.1 Each additional sheet above the anchor sheet shall be lapped a minimum of two inches (2 in.) over the preceding sheet and shall be thoroughly mopped between sheets with a bituminous compound, or other approved adhesive providing equivalent bond, so that in no place felt touches felt.

4.8.2 Sheets shall be embedded without wrinkles or buckles.

4.8.3 Each sheet, like the anchor sheet, shall be turned up vertical surfaces a minimum of four inches (4 in.).

4.8.4 (aa) Polymer modified bitumen membranes may be applied as a single ply over a mechanically fastened anchor sheet without additional plies where slopes exceed one eighth inch ($^1/_8$ in.) per foot. An additional ply is required for slopes less than $^1/_8$ in. per foot. Slope requirement applies to new roofs, recover roofs and reroofs.

4.8.5 Polymer modified bitumen membranes shall not be applied to slopes exceeding three inches (3 in.) per foot. At slopes exceeding one inch (1 in.) per foot, they shall be backnailed four inches (4 in.) from the upper edge at maximum twenty-four inches (24 in.) on center.

4.8.6 Polymer modified bitumen must be applied utilizing hot or cold adhesives as specified in Section 3.2.

4.9 FELT FLASHINGS:

4.9.1 Flashing used in the construction of built-up roof coverings shall be carried over cant strips, where provided, and turned up all walls and other vertical surfaces a minimum of eight inches (8 in.) and maximum of twenty four inches (24 in.).

4.9.2 Each layer of flashing shall be uniformly mopped with hot asphalt applied in a quantity not less than 25 pounds plus or minus 15 percent per roofing square for each mopping, or attached with approved cold adhesive providing equivalent bond.

4.9.3 Flashing turned up vertical surfaces shall be not less than one #30 felt starting four inches (4 in.) out from the cant strip and carried up such vertical surfaces not less than six inches (6 in.), and one mineral surfaced felt starting six inches (6 in.) out from the cant strip and carried up a minimum of eight inches (8 in.) above the top of the cant.

4.9.4 Such flashing shall be fastened to the wall one and one-half inches ($1^1/_2$ in.) down from the upper edge every six inches (6 in.) after which the top edge shall be finished with a three inch (3 in.) strip of membrane set in roofing cement (ASTM D 4586).

4.10 VALLEYS:

4.10.1 Valleys shall be metal, as set forth in Section 1517.6, *Florida Building Code, Building*.

4.11 PARAPET WALLS: Built-up roof covering felts shall not wrap over walls more than 24 in. in height above the deck and, where wrapped, shall be applied as follows:

4.11.1 Flashing turned up vertical surfaces shall be not less than one #30 felt starting four inches (4 in.) out from the cant strip and carried up the face over the top of the parapet, and one mineral surfaced rolled roofing (ASTM D 249) starting six inches (6 in.) out from the cant strip and carried up and over the parapet to within three inches (3 in.) of the outside edge and fastened six inches (6 in.) on center.

4.11.2 The resulting edge shall then be finished with either a three inch (3 in.) strip of membrane set in roofing cement (ASTM D 4586) and painted with aluminum paint or coping installed in accordance with Section 1517.6 of the *Florida Building Code, Building*.

4.12 INSULATION: Roof insulation may be applied under or over an anchor sheet and, where provided shall be attached as set forth in Section 5 herein.

4.13 SURFACING:

4.13.1 Mineral surfaced roofing shall not be applied on inclines one-half inch ($^1/_2$ in.) or less per foot and, where used, shall be applied only over anchor sheets and mopped in as provided in Section 4.8 herein, and on inclines five inches (5 in.) or more per foot, such caps shall be backnailed 18 inches on center.

4.13.2 Cap-surfacing with smooth or mineral surfaced felts of glass, or modified bitumen of SBS shall not be limited to slope requirements and may be:

4.13.2.1 One layer of mineral surfaced fiberglass felt.

4.13.3 COATINGS

4.13.3.1 Coatings shall be applied no later than 60 days after installation of membrane. Surface shall be clean and dry when coating is applied. Roof to be coated shall not be glaze coated. Coatings shall be applied in a uniform coverage with no asphalt showing through.

4.13.3.2 Aluminum pigmented coatings conforming to ASTM D 2824, Type I or III shall be applied at a minimum rate of 1.5 gallons per 100 square feet.

4.13.3.3 Emulsion coatings conforming to ASTM D 1227, Type III or IV shall be applied at the minimum rate of 3 gallons per 100 square feet.

4.13.3.4 Acrylic coatings shall not be applied on slopes less than $^1/_4$ in. per foot, and when used, shall be applied at the rate recommended by the coating manufacturer.

5. ROOF INSULATION

5.1 Application: Roof insulation shall provide an acceptable base for built-up, polymer-modified bitumen, or single-ply roof coverings, or shall become a part of such roof coverings as follows:

5.1.1 Over Wood Decks: Roof insulation shall be mechanically fastened directly to wood decks or shall be solidly mopped over an anchor sheet as set forth in Section 4.2 herein.

5.1.2 Over Other Nailable Decks: To reduce moisture absorption from the deck and preserve the insulating effectiveness, roof insulation shall be applied over an anchor sheet.

5.1.3 Insulation may be fully mopped to an anchor sheet on a nailable deck without any fasteners in the insulation.

5.1.4 Over Nonnailable Decks:

5.1.4.1 Roof insulation shall be solid-mopped as provided in Sections 4.5 and 4.6 herein for anchor sheet attachment to nonnailable roof decks.

5.1.4.2 Insulation used over structural or precast concrete deck shall be a maximum of 4' x 4' and fully mopped to the deck.

5.1.4.3 Over metal decks, roof insulation shall be mechanically attached per Table 2.

5.1.5 Over Anchor Sheet: Roof insulation applied over anchor sheets, attached as set forth in Section 4

TABLE 2
MECHANICALLY FASTENED INSULATION
FOR BUILDINGS 40 FEET OR LESS IN HEIGHT

	FASTENERS PER BOARD [1,5,6]		
BOARD SIZE	**FIELD**	**PERIMETER**[2]	**CORNERS**[3]
WOOD FIBERBOARD			
2 x 4 1 inch minimum	2	3	4(4)
2 x 4 1 inch minimum	4	6	8(4)
4 x 8 1 inch minimum	8	12	16(4)
FIBERGLASS			
4 x 4 $^{3}/_{4}$ inch minimum	5	8	11
4 x 4 1.5 inch minimum	4	6	8
PERLITE			
2 x 4 1 inch minimum	4	6	8(4)
ISOCYANURATE			
4 x 4 1.3 inch minimum	5	8	11
4 x 4 1.5 inch minimum	4	6	8

FOOTNOTES

(1) Minimum 3-inch plates must be used

(2) Perimeter: Defined as the first board or a minimum of 4 feet from the roof edge.

(3) Corners: Defined as 8 feet in from each side.

(4) If the building has parapet walls 36 inches or higher around the entire roof perimeter, use the number of fasteners for the perimeter.

(5) Wood and Steel decks use a minimum #12 screw and penetrate through the deck a minimum of $^{1}/_{2}$ inch.

(6) The installation of Polymer Modified Bitumen as a single-ply directly applied over mechanically fastened insulation requires DOUBLE the amount of fasteners in the field, perimeter and corners.

herein shall be solid-mopped in as provided in Section 8 herein.

5.1.6 Under Anchor Sheet:

5.1.6.1 Where more than one layer of roof insulation is provided, each successive layer shall be solid-mopped in and all joints shall be staggered.

5.1.6.2 Anchor sheets applied over such insulation shall be solid-mopped thereto, or mechanically fastened through the insulation to nailable decks with approved fasteners spaced as set forth in Table 1 and the mechanical fastening of the insulation may be omitted.

5.1.6.3 Additional built-up roofing above the anchor sheet shall be mopped in place as provided in Section 4.8 herein.

5.1.6.4 Attachment of other roof coverings over roof insulation shall comply with the specific provisions set forth in this RAS.

6. Roof Incline:

6.1 Roof insulation applied to roof with inclines of 3 or more inches per foot (1 inch per foot on steel decks) shall be nailed, screwed or bolted through tin-caps spaced not more than 12 inches on centers both ways.

6.2 Only ASTM D 312 Type III or IV asphalt shall be used on such applications.

7. Vapor Retarders: Where vapor retarders are specified, they shall be as follows:

7.1 Over wood and other nailable decks, vapor retarders shall be not less than two #15 felts lapped 19 inches, or one #30 felt lapped 4 inches, solidly mopped to anchor sheet.

7.2 Over nonnailable decks, vapor retarders shall be not less than two #15 pound felts, lapped 19 inches, shingled in and solidly mopped with hot bitumen.

8. Mopping: Solid mopping shall be hot bitumen applied in a quantity of not less than 25 pounds per roofing square at temperatures as set forth in Section 3.3 and roof insulation shall be laid with staggered joints and pressed firmly into position while such mopping is hot.

TESTING APPLICATION STANDARD (TAS) No. 100-95

TEST PROCEDURE FOR WIND AND WIND DRIVEN RAIN RESISTANCE OF DISCONTINUOUS ROOF SYSTEMS

1. Scope

1.1 This Protocol covers the determination of the water infiltration resistance of all discontinuous roof systems, consisting of a prepared roof covering and underlayment, when applied at slopes of 2 in:12 in. or greater over a nailable deck.

1.2 The test procedures outlined in this Protocol determine whether a discontinuous roof system, consisting of an underlayment and a prepared roof covering, provides sufficient wind driven rain resistance to allow no water infiltration through the deck sheathing during a predetermined test period.

1.3 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a Professional Engineer or Registered Roof Consultant.

2. Referenced Documents

2.1 *ASTM Standards:*

D1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.2 *International Conference of Building Officials*
Acceptance Criteria for Special Roofing Systems

2.3 *The Florida Building Code, Building.*

2.4 *The American Plywood Association*
Performance Standards and Polices for Structural-Use Panels

2.5 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units

3.1 Definitions - For definitions of terms used in this specification, refer to ASTM D 1079, Chapters 2 and 15 (High-Velocity Hurricane Zones) *Florida Building Code, Building*; and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use

4.1 The test procedure provides a means for establishing the resistance to wind driven rain of the discontinuous roof system, consisting of underlayment and a prepared roof covering. This test procedure has not been contemplated to measure the performance of the prepared roof covering and underlayment to maximum winds and/or uplift forces anticipated in Chapter 15, High-Velocity Hurricane Zone, of the *Florida Building Code, Building.*

5. Apparatus

5.1 The Test Frame

5.1.1 The test frame shall consist of a 10' long x 8' wide base structure, constructed from wood or steel framing, and a wood deck, constructed from plywood sheathing. Deck support joists shall be placed at 24 in. centers (See Figure 1, attached). The deck slope shall be adjustable or multiple interchangeable decks shall be available to test specimens at slopes of 2 in., 3 in., $3^1/_2$ in., 4 in., 5 in. and 6 in. in 12 in. The deck support assembly shall be capable of supporting not less than 55 lb per square foot of dead load.

5.1.2 The test frame shall not be constructed against the side of a wall or other structure which is taller than the frame.

5.1.3 The test frame shall be rigidly supported during the test period.

5.2 The Wind Generator(s)

5.2.1 The wind generator(s) shall provide a constant wind profile over the entire width of the test specimens for the specified time period to a maximum wind speed of 110 mph.

5.2.2 If the wind generator(s) is unable to provide the required constant profile, as determined by windstream calibration (Section 7.1), airflow from the wind generator(s) shall be directed and smoothed by suitably shaped baffles. (See Figure 2, attached)

5.3 Water Supply

5.3.1 Water shall be supplied to the wind stream using a sprinkle-pipe system mounted on a movable frame capable of simulating a uniform 8.8 in. per hour of rainfall over the test specimen. The simulated rainfall and flow meters shall be calibrated and the water distribution shall be checked as noted in Sections 7.2 and 7.3 , respectively.

6. Test Limitations and Precautions

6.1 During the test, all testing agency representatives and other test observers shall wear ear and eye protection and hard hats to prevent injury.

6.2 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Calibration

7.1 Windstream Calibration:

7.1.1 Prior to conducting the test, the windstream velocity shall be measured on a vertical plane grid, having dimensions of 8' wide by 4' high and grid dimensions of 24 in. x 24 in., located two feet in front of the test frame with the lower eight foot dimension in line with the front edge of the test frame (See Figure 2, attached).

7.1.2 The measured windstream velocity within each grid square shall be within ±10% of the required axial velocity for each wind speed. The windspeed shall be measured using a pitot tube connected directly to a U-tube or calibrated pressure sensing device such as a magna helix gauge. Convert the reading of inches of water to miles per hour (MPH). Pressure sensing device shall be capable of reading to the nearest 0.1 inch of water.

7.1.3 Calibration of the wind stream velocity shall be conducted every six months or whenever any change is made to any wind tunnel component.

7.2 Simulated Rainfall and Flow Meter Calibration - A maximum of three months prior to conducting the test, the flow meter(s) shall be calibrated using the following method:

7.2.1 Capture water from the exit of the flow meters in a five gallon bucket which has been weighed.

7.2.2 Allow water to flow through the flow meter into the tared 5 gallon bucket for a period of 1 minute. Set the flow meters to deliver 8.8 inches of water per hour and record the flow meter reading in gallons per minute during the process.

7.2.3 Convert the flow meter reading $(^{\text{gallons}}/_{\text{minute}})$ to rainfall simulation $(^{\text{inches}}/_{\text{hour}})$ using the following formula:

$$\left[\frac{\left(\frac{\text{gallons}}{\text{minute}}\right)\times\left(\frac{60\text{ minutes}}{1\text{ hour}}\right)\times\left(\frac{231\text{ in}^3}{1\text{ gallon}}\right)}{11{,}520\text{ in}^2}\right]=\left(\times\,\frac{\text{inches}}{\text{hour}}\right)$$

7.2.4 The quantity of rainfall simulation determined in 7.2.3 shall be within ± 5% of the desired rainfall simulation of 8.8 $^{\text{inches}}/_{\text{hour}}$.

7.2.5 Measure the volume of water (in^3) captured and convert this to rainfall simulation $(^{\text{inches}}/_{\text{hour}})$ using the following formula:

$$\left[\frac{\left(\frac{\text{inches}^3}{11{,}520\,\text{inches}^2}\right)}{1\,\text{minute}}\times\left(\frac{60\,\text{minutes}}{1\,\text{hour}}\right)\right]=\left(y\,\frac{\text{inches}}{\text{hour}}\right)$$

7.2.6 The rainfall simulation determined in 7.2.3 (x) shall be within ± 5% of the rainfall simulation determined in 7.2.5 (y).

7.3 Water Distribution Check - The water distribution check over the (8 ft. x 10 ft.) flat test deck (without valley) shall be checked and calibrated every six months using the method outlined herein. Water distribution system must be adjusted so that the water introduced into the wind stream strikes the deck.

7.3.1 Prepare ten (10) 24 in. squares of thick absorptive material and weigh each sample. From this data, determine the average weight of the samples.

7.3.2 Prepare twenty (20) numbered squares of absorptive material and lay out on deck four horizontally across the deck and five vertically up the deck. Place a hold-down frame over the test deck and squares of absorptive material.

7.3.3 Set the test frame to 2 inches per foot of slope.

7.3.4 Set the wind speed to 35 mph and add water to the windstream at a constant rate, as indicated on the flow meter, until the absorptive material is wet but not saturated, at which time the wind and water flow shall be terminated. Record the duration of time required to 'wet' the material.

7.3.5 Remove the hold-down frame from the deck and rapidly weigh the squares of wet absorptive material. Determine the weight of water striking each square sample at the particular wind speed and flow meter setting.

7.3.6 No one particular square sample shall exhibit rainfall simulation, measured in weight, greater than or less than 25% of the average weight of all twenty squares.

7.3.7 Repeat steps 7.3.2 through 7.3.5 at a wind speed of 70 mph.

7.3.7.1 No one particular square sample shall exhibit a rainfall simulation, measured in weight, greater than or less than 25% of the average weight of all 20 squares.

8. Test Specimens

8.1 Deck

8.1.1 The wood test deck shall consist of APA 32/16 span rated sheathing of $^{15}/_{32}$ in. thickness installed over 2 in. x 6 in. perimeter supports and 2 in. x 6 in. intermediate supports spaced 24 in. apart. The sheathing shall be attached with 8d common nails at 6 in. o.c. at panel edges and 12 in. o.c. at intermediate supports. One valley shall be constructed into the test deck, located at the deck's front edge, as noted on Figure 1, attached.

8.1.2 The wood test deck shall be positioned at the minimum slope, as applicable in the High-Velocity Hurricane Zone jurisdiction, for the type of discontinuous roof system being tested, but not less than 2 in:12 in.

8.2 Underlayment and Prepared Roof Covering

8.2.1 Underlayment and prepared roof covering shall be installed in strict compliance with the manufacturer's published installation instructions and the minimum installation requirements set forth in Section 1518 of the *Florida Building Code, Building*. The requirements of the *Florida Building Code, Building* shall take precedence.

8.3 The areas subject to the test criteria shall consist of the field area of the test deck, the eave, the valley, one rake section.

8.4 The test specimen shall be inspected by a Professional Engineer or Registered Roof Consultant who shall confirm in the final report that the method of construction is in compliance with the specifications of this protocol.

9. Conditioning - conditioning need not be performed on mechanically attached, rigid, discontinuous roof systems.

9.1 Conditioning shall consist of three days of exposure to outside environmental conditions during which time the surface temperature of the prepared roof covering shall reach not less than 135°F for a period of six hours in each day. The surface temperature shall be measured with a surface mounted thermocouple and recorded to confirm that the specified surface temperature is attained for the specified period of time on each day.

9.2 Should the surface temperature fail to reach the specified temperature for the specified time period on each of three days, the test deck shall be conditioned for one additional day or until the surface temperature has been at 135°F for a total of 18 hours.

9.3 As an alternative, conditioning may consist of 16 continuous hours of deck exposure to minimum relative humidity of 80% ±5% and a minimum temperature of 135°F to 140°F in a closed cell or room.

9.4 Care must be taken not to damage, twist or distort the test specimen during handling as this may affect the test specimen's performance.

9.5 After the conditioning procedure is complete, the test deck shall be allowed to come to ambient temperature prior to testing.

10. Test Procedure

10.1 The test specimen shall be positioned on the test frame at the minimum slope proposed for installation but not less than 2 in:12 in.

10.2 The test specimen shall be positioned so that the exposed edge of the 8 foot eave is facing the wind generator(s) and to accommodate an observer under the deck for the duration of the test period.

10.3 The topside and underside of the test specimen shall be photographed immediately prior to starting the test.

10.4 The wind speed intervals shall be conducted as noted below.

Interval #	Wind speed (mph)	Time (min.)
1	35	15
2	0	10
3	70	15
4	0	10
5	90	15
6	0	10
7	110	5
8	0	10

The test shall terminate at the end of the final ten (10) minute 0 mph interval.

10.5 Water shall be added to the windstream upon commencement of the initial wind speed, upwind from the test deck, in an even spray, at a rate to simulate 8.8 in. per hour of rainfall over the test specimen. The flow of water shall be measured with a calibrated flow meter during the test procedure to confirm water flow. Water flow shall be stopped and started in conjunction with the air flow intervals noted in 10.4. Photographs shall be taken of the top side and underside of the test specimen 30 seconds prior to the completion of each interval noted in Section 10.4.

10.6 The observer shall monitor any water infiltration from the underside of the test specimen, recording approximate quantities penetrating the deck structure during the test period. Should the volume of water increase to a steady dripping in three or more places during the test period, the test shall be terminated prior to maximum wind speed. Water penetrating the test shall be contained and measured. The observer shall also monitor any damage to the test specimen or any component thereof.

10.7 The top side and underside of the test specimen shall be photographed immediately subsequent to test termination.

11. Report

11.1 The final test report shall include the following:

11.1.1 A description of the discontinuous roof system, including the manufacturer and type of underlayment; the manufacturer and type of prepared roof covering; the slope(s) at which the system was tested.

11.1.2 A detailed report of the method of construction, including a sketch of the test specimen; certification by a Professional Engineer or Registered Roof Consultant that the test specimen was constructed in compliance with the specifications of this Protocol; and, a copy of the published application instructions provided by the prepared roof covering manufacturer.

11.1.3 A description of the method of conditioning used.

11.1.4 A description of the absorptive material used during the water distribution check.

11.1.5 Photographs of the top side and underside of the test specimen immediately prior and subsequent to commencement and termination of testing, respectively.

11.1.6 Photographs of the top side and underside of the test specimen 30 seconds prior to completion of each interval noted in Section 10.4.

11.1.7 All windstream calibration data (from Section 7.1); simulated rainfall and flow meter calibration data and calculations (from Section 7.2); and water distribution data and calculations (from Section 7.3).

11.1.8 Detailed observations of water infiltration through the sheathing and the times and locations of water infiltration.

11.1.9 The volume of water (if any) which infiltrated the sheathing in the area of the ridge vent on the second test specimen and was contained.

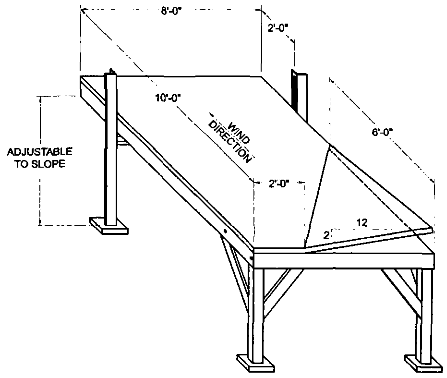
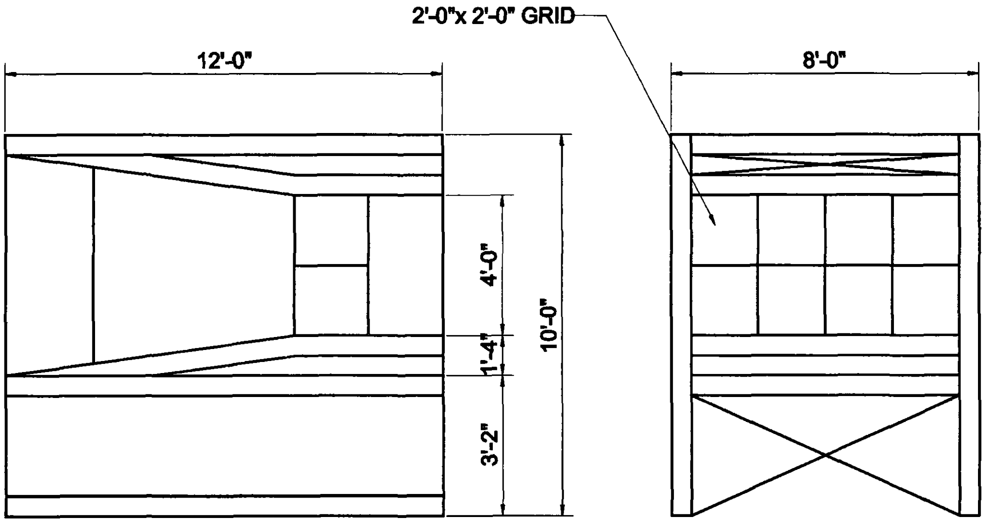


FIGURE 1
WIND-DRIVEN RAIN TEST FRAME



WIND TUNNEL WITH BAFFLES
SIDE VIEW

WIND TUNNEL WITH BAFFLES
DOWNSTREAM VIEW

FIGURE 2
WIND DRIVEN RAIN WIND TUNNEL

11.1.10 Any test specimen which exhibits water infiltration through the sheathing shall be considered as failing the wind driven rain test.

11.1.11 Any test specimen which has the prepared roof covering or any portion thereof 'blow off', tear or blow upward without reseating during the test shall be considered as failing the wind driven rain test.

TESTING APPLICATION STANDARD (TAS) No. 100(A)-95

TEST PROCEDURE FOR WIND AND WIND DRIVEN RAIN RESISTANCE AND/OR INCREASED WINDSPEED RESISTANCE OF SOFFIT VENTILATION STRIP AND CONTINUOUS OR INTERMITTENT VENTILATION SYSTEM INSTALLED AT THE RIDGE AREA

1. Scope

1.1 This Protocol covers the determination of the water infiltration resistance of a soffit ventilation and a continuous or intermittent ridge area ventilation system (i.e. ridge vents, static vents, turbines or powered vents) installed on a test specimen consisting of an underlayment, prepared roof covering, the soffit ventilation, and the ridge area ventilation system, when applied at slopes of 2 in:12 in. or greater over a nailable deck.

1.2 The test procedures outlined in this Protocol determine whether a soffit ventilation and a continuous or intermittent ridge area ventilation system installed within a discontinuous roof system, consisting of an underlayment and a prepared roof covering, provides sufficient wind driven rain resistance to allow minimal water infiltration through the soffit and ridge area vent during a predetermined test period.

1.3 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a Professional Engineer or Registered Roof Consultant.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.2 *International Conference of Building Officials*
Acceptance Criteria for Special Roofing Systems

2.3 *The Florida Building Code, Building.*

2.4 *The American Plywood Association*
Performance Standards and Polices for Structural-Use Panels

2.5 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units

3.1 Definitions - For definitions of terms used in this specification, refer to ASTM D 1079, Chapters 2 and 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*; and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380

4. Significance and Use

4.1 The test procedure provides a means for establishing the resistance to wind driven rain of a continuous or intermittent ridge area ventilation system when installed in a discontinuous roof system, consisting of underlayment and a prepared roof covering. This test procedure has not been contemplated to measure the performance of the prepared roof covering and underlayment to maximum winds and/or uplift forces anticipated in the High-Velocity Hurricane Zone jurisdiction.

5. Apparatus

5.1 The Test Frame

5.1.1 The test frame shall consist of a base structure of sufficient dimensions to hold the test specimen noted in Section 8, constructed from wood or steel framing, and a wood deck, constructed from plywood sheathing. Deck support joists shall be placed at 24 in. centers. (See Figure 1, attached.) The deck slopes, on the windward and leeward side, shall be adjustable or multiple interchangeable decks shall be available to test assemblies at slopes of 2 in., 4 in. and 6 in. in 12 in. The deck support assembly shall be capable of supporting not less than 55 lbs per square foot of dead load. The windward end and each side of the test frame shall be covered with plywood to insure soffit to ridge airflow.

5.1.1 The test frame shall not be constructed against the side of a wall or other structure which is taller than the frame.

5.1.2 The test frame shall be rigidly supported during the test period.

5.2 The Wind Generator(s)

5.2.1 The wind generator(s) shall provide a constant wind profile over the entire width of the test deck for the specified time period to a maximum wind speed of 110 mph for ridge vent testing and 140 mph for other ventilation components.

5.2.2 If the wind generator(s) is unable to provide the required constant profile, as determined by windstream calibration (Section 7.1), airflow from the wind generator(s) shall be directed and smoothed by suitably shaped baffles. (See Figure 2, attached.)

5.3 Water Supply

5.3.1 Water shall be supplied to the wind stream using a sprinkle-pipe system mounted on a movable frame capable of simulating a uniform 8.8 in. per hour of rainfall over the test specimen. The simulated rainfall and flow meters shall be calibrated and the water distribution shall be checked as noted in Sections 7.2 and 7.3, respectively.

6. Test Limitations and Precautions

6.1 During the test, all testing agency representatives and other test observers shall wear ear and eye protection and hard hats to prevent injury.

6.2 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Calibration

7.1 Windstream Calibration

7.1.1 Prior to conducting the test, the windstream velocity shall be measured on an 8' wide vertical plane grid, of sufficient height to encompass the entire frontal profile of the test specimen placed at the test slope, having grid dimensions of 24 in. x 24 in., located two feet in front of the test frame with the lower eight foot dimension in line with the front edge of the test frame. (See Figure 2, attached.)

7.1.2 The measured windstream velocity within each grid square shall be within ± 10% of the required axial velocity for each wind speed.

7.2 Simulated Rainfall and Flow Meter Calibration - A maximum of three months prior to conducting the test, the flow meter(s) shall be calibrated using the following method:

7.2.1 Prepare an apparatus to capture any water which would enter the windstream during an actual test.

7.2.2 Commence water insertion for a period of one (1) minute and capture the water. Record the flow meter reading $(^{\text{gallons}}/_{\text{minute}})$ during this process.

7.2.3 Convert the flow meter reading $(^{\text{gallons}}/_{\text{minute}})$ to rainfall simulation $(^{\text{inches}}/_{\text{hour}})$ using the following formula:

$$\left[\frac{\left(\frac{\text{gallons}}{\text{minute}}\right)\times\left(\frac{60\,\text{minutes}}{1\,\text{hour}}\right)\times\left(\frac{231\,\text{in}^3}{1\,\text{gallon}}\right)}{6{,}912\,\text{in}^2}\right]=\times\left(\frac{\text{inches}}{\text{hour}}\right)$$

7.2.4 The quantity of rainfall simulation determined in 7.2.3 shall be within ± 5% of the desired rainfall simulation of 8.8 $^{\text{inches}}/_{\text{hour}}$.

7.2.5 Measure the volume of water (in^3) captured and convert this to rainfall simulation $(^{\text{inches}}/_{\text{hour}})$ using the following formula:

$$\left[\frac{\left(\frac{\text{inches}^3}{6{,}912\,\text{inches}^2}\right)}{1\,\text{minute}}\right]\times\left(\frac{60\,\text{minutes}}{1\,\text{hour}}\right)=\left(y\,\frac{\text{inches}}{\text{hour}}\right)$$

7.2.6 The rainfall simulation determined in 7.2.3 (x) shall be within ± 5% of the rainfall simulation determined in 7.2.5 (y).

7.3 Water Distribution Check - Prior to conducting the test, the water distribution over the test frame shall be checked and calibrated using the method outlined herein.

7.3.1 Prepare ten (10) 24 in. squares of thick absorptive material and weigh each sample. From this data, determine the average weight of the samples.

7.3.2 Prepare a 9' x 7' sheet of the absorptive material and mark the sheet with 12 24 in. squares centered on the sheet, leaving a 6 in. perimeter area unmarked.

7.3.3 Set the test frame to the desired slope and attach an 8' wide by 6' long sheathing panel, of the type specified in Section 8.1, to the test frame with the absorptive material centered on the sheathing. Fold the 6 in. material perimeter down over the test fame perimeter and clamp into place using 2 in. x 4 in. blocking and C-clamps.

7.3.4 Set the wind speed to 35 mph and add water to the windstream at a constant rate, as indicated on the flow meter, until the absorptive material is wet but not saturated, at which time the wind and water flow shall be terminated. Record the duration of time required to "wet" the material.

7.3.5 Remove the C-clamps and blocking and cut the material into the premarked 24 in. squares. Using the average dry weight of the material squares (determined in 7.3.1) and the weight after exposure, determine the volume of water (in^3) striking each square sample at the particular wind speed and flow meter setting.

7.3.5.1 Determine the rain simulation $(^{\text{inches}}/_{\text{hour}})$ absorbed into each square sample using the following formula:

$$\left[\frac{\left(\frac{\text{volume of water (in}^3)}{576\,\text{in}^2}\right)}{\text{time duration (hours)}}\right]=\times\left(\frac{\text{inches}}{\text{hour}}\right)$$

7.3.6 No one particular square sample shall exhibit a rainfall simulation (determined in 7.3.5.1) greater than or less than 15% of any other square sample.

7.3.7 Repeat steps 7.3.2 through 7.3.5 at a wind speed of 70 mph.

7.3.7.1 No one particular square sample shall exhibit a rainfall simulation (determined in 7.3.5.1) greater than or less than 10% of any other square sample.

8. Test Specimens

8.1 Deck

8.1.1 The wood test deck shall consist of APA $^{32}/_{16}$ span rated sheathing of $^{15}/_{32}$ in. thickness installed over 2 in. x 6 in. perimeter supports and 2 in. x 6 in. intermediate supports spaced 24 in. apart. The sheathing shall be attached with 8d common nails at 6 in. o.c. at panel edges and 12 in. o.c. at intermediate supports. The 'windward deck' shall be 8' wide by 6' long and the leeward deck shall be 8' wide by 1' 6 in. long and shall overhang the leeward end of the test frame.

8.1.2 Sheathing panels, which meet at the ridge, shall be installed such that a gap exists along the ridge. The gap size shall be specified by the ridge ventilation system manufacturer; but shall not exceed 3.5 in. in width.

8.1.3 The type of soffit ventilation shall be specified by the ridge ventilation system manufacturer; but the net free area shall be equal to 72 ± 5 in^2. The soffit ventilation assembly shall be installed beneath the windward eave of the test specimen. (See Figure 1, attached.)

8.1.3.1 The testing agency shall confirm that adequate soffit to ridge ventilation exists prior to conducting the wind driven rain test.

8.1.4 A tray shall be installed on the underside of the ridge area to capture any water which infiltrates the ridge area ventilation system. The tray shall be sized and configured to insure that all water penetrating the ridge area ventilation system or the ventilation unit, is captured.

8.1.5 The wood test deck shall be positioned at the minimum slope, as applicable in the High-Velocity Hurricane Zones jurisdiction, for the type of ridge area ventilation system being tested, but not less than 2 in:12 in. (See Figure 1, attached.)

8.2 Underlayment, Prepared Roof Covering and Ridge Area Ventilation System

8.2.1 The underlayment, prepared roof covering, soffit ventilation and ridge area ventilation system (i.e., ridge vent, static vents, turbines or powered vents) shall be installed in strict compliance with the respective manufacturer's published installation instructions and the minimum installation requirements set forth in Section 1518 of the *Florida Building Code, Building*. The requirements of the *Florida Building Code, Building* shall take precedence.

8.3 The areas subject to the test criteria shall consist of the soffit ventilation installed at the windward eave and the ridge area ventilation system or the two ventilation units. All continuous ridge vents shall extend six feet across the ridge, leaving one foot of ridge waterproofing in place on each side of the ridge vent. The soffit ventilation shall extend the entire 8' width of the windward eave.

8.4 Static vents, turbines or power vents shall be installed 18 in. below the ridge measured to the closest point of the unit to the ridge.

8.4.1 Two units shall be installed on the test panel, equally spaced in the center of two support joists.

8.4.2 If units are manufactured for curb mounting, a curb shall be constructed or a preformed curb shall be secured to the test deck. The construction of the curb and its attachment shall be detailed in the test report.

8.4.3 The ventilation component shall be secured to the test deck with fasteners and/or nails in compliance with the component manufacturer's current, published installation instructions.

8.4.4 The method of application, including a detail drawing, shall be included in the test report.

8.4.5 Turbines shall be installed with the turbine component in place.

8.4.6 Turbine caps shall be available for installation at windspeeds greater than 70 mph during the test procedure.

8.5 The test specimen shall be inspected by a Professional Engineer or Registered Roof Consultant who shall confirm in the final report that the method of construction is in compliance with the specifications of this protocol.

9. Conditioning - conditioning need not be performed on ventilation systems designed for use with mechanically attached, rigid, discontinuous roof systems.

9.1 Conditioning shall consist of three days of exposure to outside environmental conditions during which time the surface temperature of the prepared roof covering shall reach not less than 120°F for a period of six hours in each day. The surface temperature shall be measured with a surface mounted thermocouple and recorded on a chart recorder to confirm that the specified surface temperature is attained for the specified period of time on each day.

9.2 Should the surface temperature fail to reach the specified temperature for the specified time period on each of three days, the test deck shall be conditioned for one additional day or until the surface temperature has been at 120°F for a total of 18 hours.

9.3 As an alternative, conditioning may consist of 16 continuous hours of test specimen exposure to a minimum relative humidity of 80% ± 5% and a minimum temperature of 120°F to 135°F in a closed cell or room.

9.4 Care must be taken not to damage, twist or distort the deck during handling as this may affect the test specimen's performance.

9.5 After the conditioning procedure is complete, the test deck shall be allowed to come to ambient temperature for a period of not less than four hours prior to testing.

10. Test Procedures

10.1 The test specimen shall be positioned on the test frame at the minimum slope proposed for installation, but not less than 2 in:12 in.

10.2 The test specimen shall be positioned so that the exposed edge of the 8 foot eave is facing the wind generator(s) and to accommodate an observer under the deck for the duration of the wind driven rain test period noted in Section 10.4.

10.3 Wind-Driven Rain Testing

10.3.1 The underside of the soffit ventilation, ridge vent or ventilation unit shall be photographed immediately prior to starting the wind driven rain test.

10.3.2 The wind speed intervals shall be conducted as noted in Table 1, below.

TABLE 1
WINDSPEED AND WATER SPRAY INTERVALS FOR WIND DRIVEN RAIN RESISTANCE TESTING

Interval #	Wind Speed (mph)	Time (min)	Water Spray
1	35	15	on
2	0	5	off
3	70	15	on
4	0	5	off
5	90	15	on
6	0	5	off
7	110	5	on
8	0	5	off

[1] If the ventilator is a turbine vent, the turbine unit shall be removed at the conclusion of interval #3 and replaced with a "storm cap" for the duration of testing, including increased windspeed testing noted in Section 10.5.

10.3.3 Water shall be added to the windstream upon commencement of the initial wind speed, upwind from the test deck, in an even spray, at a rate equal to 8.8 in. per hour of rainfall over the test specimen. The flow of water shall be measured with a calibrated flow meter during the test procedure to confirm water flow. Water flow shall be stopped and started in conjunction with the air flow intervals noted in Table 1.

10.3.4 An observer shall monitor any water infiltration from the underside of the soffit ventilation strip or ventilation unit, recording approximate quantities penetrating the test deck during the test period. The observer shall also monitor any damage to the test specimen or any component thereof. Water penetrating the ridge area ventilation system or ventilation unit shall be gathered from the tray and measured.

10.3.5 Any visible, unusual occurrences at the soffit or ridge ventilation areas or ventilation unit during the wind driven rain test shall be photographed.

10.3.6 If the ventilator is a turbine vent, the turbine unit shall be removed at the conclusion of interval #3 and replaced with the 'storm cap' for the duration of testing, including increased windspeed testing noted in Section 10.4.

10.3.7 The underside of the soffit ventilation strip, ventilation unit and/or ridge vent shall be photographed immediately subsequent to test termination.

10.4 Increased Wind-Resistance Testing

10.4.1 Static vents, turbines, powered vents or other protruding roof top components, having a height less than or equal to 12 in. and any other dimension less than or equal to 18 in. may be tested for resistance to increased windspeeds following windspeed intervals noted in Table 2, below.

TABLE 2
WINDSPEED INTERVALS FOR INCREASED WIND RESISTANCE TESTING OF STATIC VENTS, TURBINES[1] OR POWERED VENTS

Interval #	Wind Speed (mph)	Time (min)	Water Spray[2]
1	110	1	off
2	115	1	off
3	120	1	off
4	125	1	off
5	130	1	off
6	135	1	off
7	140	1	off

[1] If the ventilator is a turbine vent, the turbine unit shall have been replaced with a storm cap subsequent to completion of Interval #3 in Table 1 or, if the increased wind resistance test is performed separately from the wind driven rain test, the "storm cap"shall be installed prior to test commencement.

[2] Water spray shall not form a portion of increased windspeed testing.

10.4.2 The ventilation unit shall be photographed immediately prior to starting the increased wind resistance test.

10.4.3 The increased windspeed resistance test procedure may be performed as a continuation of wind driven rain testing noted in Section 10.3 or may be performed as a separate test, provided the product being tested has previously passed the wind-driven rain testing noted in Section 10.3.

10.4.4 This test procedure does not include water spray, therefore, no observer shall be present under the test deck. The observer shall remain a safe distance away from the test deck to monitor and document any damage occurring to the venting unit during increased windspeeds.

10.4.5 Any visible, unusual occurrences at the ventilation unit during the increase windspeed test shall be photographed.

10.4.6 Any damage to or loss of anchorage of either of the two ventilation units shall terminate the test; the observer noting the windspeed interval and time therein at which damage or anchorage loss occurs.

10.4.7 The ventilation unit shall be photographed immediately subsequent to test termination, insuring any damage or loss of anchorage is completely documented.

10.4.8 Static vents, turbines, powered vents or other protruding roof top components, having a height greater than 12 in. or any other dimension greater than 18 in. shall be tested for resistance to wind induced pressures in compliance with TAS 100(B).

11. Interpretation of Results

11.1 Wind-Driven Rain Testing

11.1.1 For ridge vents installed directly over a ridge opening, successful completion of the test procedures outlined in Section 10.3 approves the product for installation up to and including a height of 75 feet.

11.1.2 For static vents, turbines or powered vents, which protrude from the roof level, successful completion of the test procedures outlined in Section 10.3 approves the product for installation up to and including a height of 33 feet.

11.2 Increased Windspeed Testing

11.2.1 For static vents, turbines, or powered vents, which protrude from the roof level and meet the size limitations set forth in Section 10.4.1, successful completion of windspeed increments noted in Table 2 relate to approval for product installation up to and including the heights noted in Table 3, below.

TABLE 3
INCREASED WINDSPEED VS. INSTALLATION HEIGHT

Wind Speed (mph)	Height (feet)
115	40
120	47
125	54
130	61
135	68
140	75

11.3 Maximum height of installation shall be noted in the product manufacturer's Roofing Component Product Approval based on testing in compliance with this Protocol.

11.4 Proposed installation of approved ventilation products over a height of 75 feet shall be based on written Approval from the Authority having Jurisdiction.

12. Report

12.1 The final test report shall include the following:

12.1.1 A description of the discontinuous roof system, including the manufacturer and type of underlayment; the manufacturer and type of prepared roof covering; the manufacturer, type and model number (if any) of the soffit ventilation; the manufacturer, type and model number (if any) of the ridge area ventilation system or ventilation unit; and the slope(s) at which the system was tested.

12.1.2 A detailed report of the method of construction, including a sketch of the test specimen; certification by a Professional Engineer or Registered Roof Consultant that the test specimen was constructed in compliance with the specifications of this Protocol and the manufacturers published application instructions, and, a copy of the published application instructions provided by the ridge area ventilation system or ventilation unit manufacturer.

12.1.3 A description of the method of conditioning used.

12.1.4 For Wind Driven Rain Testing

12.1.4.1 A description of the absorptive material used during the water distribution check. All windstream calibration data, simulated rainfall and flow meter calibration data and calculations, and water distribution data and calculations.

12.1.4.2 Photographs of the underside of the soffit ventilation and ridge area ventilation system or ventilation unit immediately prior and subsequent to commencement and termination of testing, respectively. Also include photographs of any visible, unusual occurrences at the soffit ventilation and ridge area ventilation or ventilation unit during the test.

12.1.4.3 Detailed observations of any water infiltration through the soffit ventilation and/or the ridge area ventilation system or ventilation unit and approximate times and locations of water infiltration.

12.1.4.4 The total volume of water (if any) which infiltrated the soffit ventilation and/or the ridge area ventilation system or ventilation unit.

12.1.4.5 The calculated percentage of water which infiltrated the ridge area ventilation system or ventilation unit based on the total amount of water sprayed at the test deck.

12.1.4.6 Any test specimen which exhibits water infiltration through the ridge area ventilation system or ventilation unit in excess of 0.05% of the total water sprayed at the test deck shall be considered as failing the wind driven rain test.

12.1.5 Increased Windspeed Resistance Testing - Report shall include all requirements noted in Section 11.1.4 if the increased windspeed resistance testing is performed as a continuation of wind driven rain testing. If the increased windspeed resistance testing is performed as a separate test, only the following need be reported.

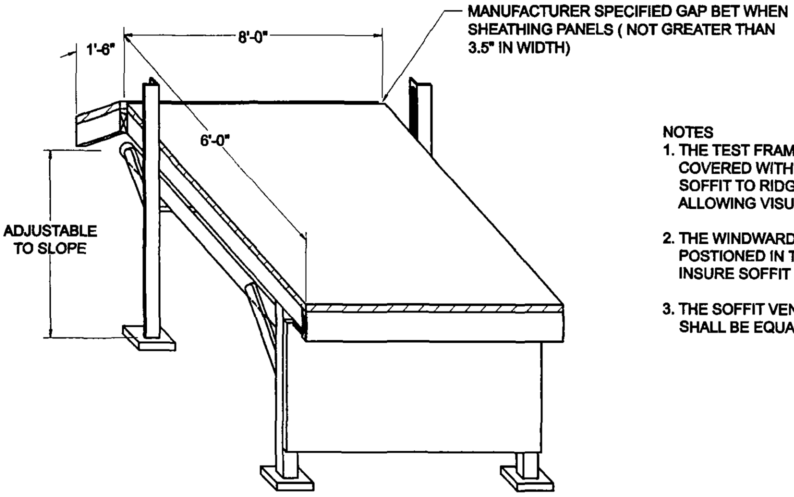
12.1.5.1 All windstream calibration data.

12.1.5.2 A description of any occurrences at the ventilation unit and to the discontinuous roof system during each wind speed interval.

12.1.5.3 Photographs of the ventilation unit immediately prior and subsequent to commencement and termination of testing, respectively. Also include photographs of any visible, unusual occurrences at the ventilation unit during the test.

12.1.5.4 A video record of the test intervals noted in Table 2.

12.1.5.5 The windspeed interval, and time therein, at which damage (if any) leading to test termination occurred and a description and photographic record of the damage.


MANUFACTURER SPECIFIED GAP BET WHEN SHEATHING PANELS (NOT GREATER THAN 3.5" IN WIDTH)
1'-6"
8'-0"
6'-0"
ADJUSTABLE TO SLOPE

NOTES

1. THE TEST FRAME UNDERSIDE SHALL BE COVERED WITH PLEXIGLASS TO INSURE SOFFIT TO RIDGE AIRFLOW WHILE STILL ALLOWING VISUAL INSPECTION OF UNDERSIDE
2. THE WINDWARD EAVE EDGE SHALL BE POSTIONED IN THE WINDSTREAM TO INSURE SOFFIT TO RIDGE AIRFLOW
3. THE SOFFIT VENTILATION NET FREE AREA SHALL BE EQUAL TO 72 +/- 5 SQ IN.

FIGURE 1A
WIND DRIVEN RAIN TEST FRAME, FRONT VIEW

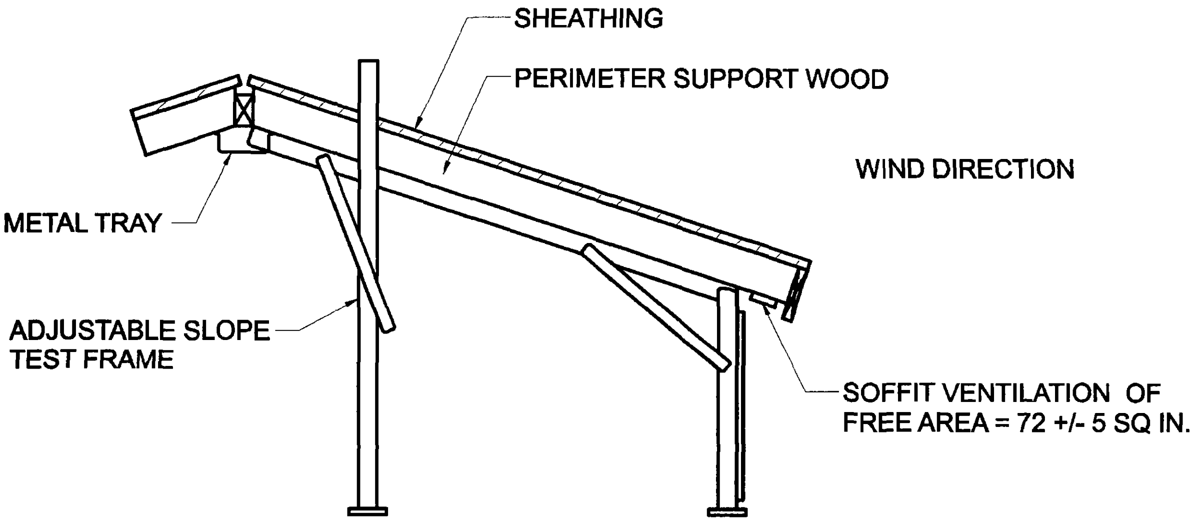

SHEATHING
PERIMETER SUPPORT WOOD
WIND DIRECTION
METAL TRAY
ADJUSTABLE SLOPE TEST FRAME
SOFFIT VENTILATION OF FREE AREA = 72 +/- 5 SQ IN.

FIGURE 1B
WIND DRIVEN RAIN TEST FRAME, SIDE VIEW

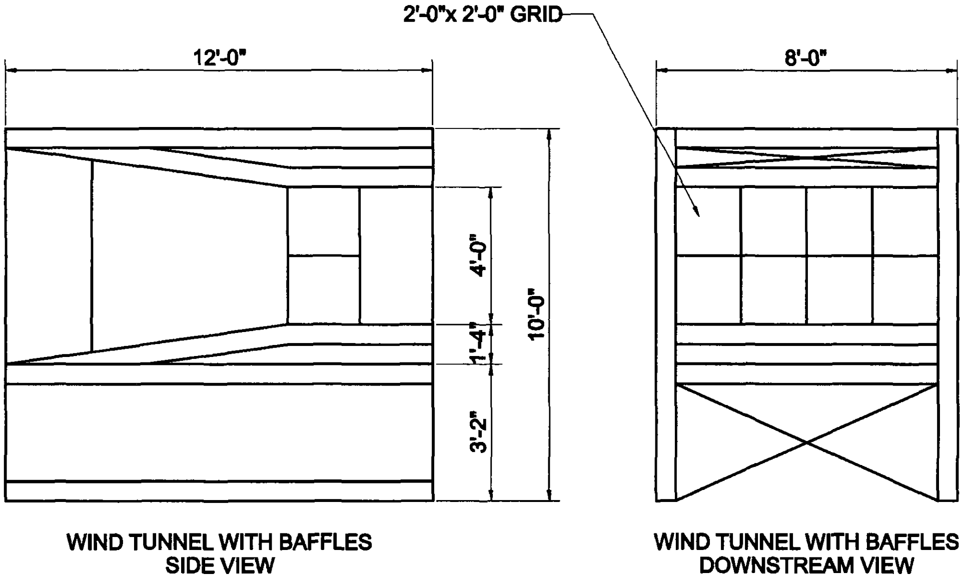


FIGURE 2
WIND DRIVEN RAIN WIND TUNNEL

TESTING APPLICATION STANDARD (TAS) No. 101-95

TEST PROCEDURE FOR STATIC UPLIFT RESISTANCE OF MORTAR OR ADHESIVE SET TILE SYSTEMS

1. Scope

1.1 This Protocol covers the determination of: 1) the average weight (W) of a tile; 2) the restoring moment due to gravity (M_g) provided by the tile's weight; 3) the minimum characteristic resistance load (F'); and, 4) the attachment resistance expressed as a moment (M_f) provided by the mortar or adhesive bond to the tile.

1.2 The test procedures outlined herein shall be used to determine: 1) the average mass (m) of the tile; and, 2) the resistance to an uplift load placed on a mortar or adhesive set tile installed on a test specimen which is set at a predetermined test slope (θ).

The point of application of the uplift load shall be dependent upon whether the system has been or is to be tested for wind characteristics in compliance with TAS 108.

Prior to conducting the testing, the tile system manufacturer shall specify to the testing agency a test slope (θ) of either 9.5° (2 in:12 in.) or 18.5° (4 in:12 in.).

1.3 The calculations outlined herein shall be used to determine: 1) the average weight (W) of the tile; 2) the restoring moment due to gravity (M_g), determined from knowledge of the tile's average weight (W) and dimensions, and the test slope (θ); 3) the minimum characteristic resistance load (F'), which is representative of the test data noted in Section 1.2; and, 4) the attachment resistance expressed as a moment (M_f) provided by the tile's bonds at the test slope (θ).

1.4 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a Professional Engineer or Registered Roof Consultant.

1.5 A margin of safety of 2:1 shall be applied to test results, as noted in Section 10.4.1.

2. Referenced Documents

2.1 The *Florida Building Code, Building*

2.2 *Application Standards*

TAS 108	Test Procedure for Wind Tunnel Testing of Air Permeable, Rigid, Discontinuous Roof Systems
RAS 127	Standard Procedure for Determining Applicability of Tile System Installation

2.3 *The American Plywood Association*
Performance Standards and Polices for Structural-Use Panels

2.4 *Redland Technologies - New Technology & Product Development Centre*
Fixing Studies for MRTI Normal Weight Tiles - SBCCI Submission

2.5 *The American Society of Civil Engineers* (ASCE)
ASCE 7; Minimum Design Loads for Buildings and Other Structures

2.6 *ASTM Standards:*

E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.7 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units

3.1 Definitions - For definitions of terms used in this specification, refer to Chapters 2 and 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*; and/or Fixing Studies for MRTI Normal Weight Tiles; and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use

4.1 The test procedures and calculations specified herein provide a means for establishing: 1) the average weight (W) of the tile; 2) the restoring moment due to gravity (M_g) provided by the tile's weight; 3) the minimum characteristic resistance load (F'); and, 4) the attachment resistance expressed as a moment (M_f) provided by the tile's bonds.

The tile's average weight (W) is a measure of it gravitational force of attraction to the earth's surface. Sea level conditions are assumed for the purposes of this Protocol.

The tile's restoring moment due to gravity (M_g) is a measure of its ability to resist a rotational force (moment) prior to its attachment (bonding) to the substrate, when positioned at the specified test slope (θ). It represents the tile's weight in terms of resisting a rotational force.

The minimum characteristic resistance load (F') represents the combined effects of the tile's weight and its bond to the substrate in their ability to resist an uplift load placed at a predetermined location on the tile.

The attachment resistance expressed as a moment (M_f) is a measure of the bond's ability to resist the rotational force incurred upon it due to the uplift load placed on the tile.

4.2 Systems which are also tested for wind characteristics (henceforth 'moment based systems'), in compliance with TAS 108, shall have: 1) the restoring moment due to gravity (M_g); 2) the minimum characteristic resistance load (F'); and, 3) the attachment resistance expressed as a moment (M_f), determined under this Protocol, listed in the system manufacturer's Product Approval for reference. These values are used, in conjunction with the system's aerodynamic multiplier (λ), also listed in the Product Approval, in the calculations and procedures outlined in RAS 127 to determine the whether the mortar or adhesive bonding is acceptable for tile system installation on a particular building in the High-Velocity Hurricane Zone jurisdiction. While the calculations and procedures noted in RAS 127 may be conducted by the Uniform Building Permit applicant, where the pressures (P) have been determined based on Table 1 and do not require additional signed and sealed engineering design calculations. All other calculations shall be conducted by a Professional Engineer or Registered Architect.

4.3 Systems which are not tested for wind characteristics (henceforth "uplift based systems,") due to size constraints, air impermeability, or manufacturer decision, shall have: 1) the tile's average weight (W); 2) the tile's length (l) and width (w); and, 3) the minimum characteristic resistance load (F') listed in the system manufacturer's Product Approval for reference. These values are used in the calculations and procedures outlined in RAS 127 to determine whether the mortar or adhesive bonding is acceptable for tile system installation on a particular building in the High Velocity Hurricane Zone jurisdiction. While the calculations and procedures noted in RAS 127 may be conducted by the Uniform Building Permit applicant, where the pressures (P) have been determined based on Table 1 and do not require additional signed and sealed engineering design calculations. All other calculations shall be conducted by a Professional Engineer or a Registered Architect.

NOTE: Uplift based systems need only be tested for average weight (W) and minimum characteristic resistance load (F') in this Protocol.

4.4 Testing in compliance with this protocol and subsequent listing of the results in the system manufacturer's Product Approval, as noted in Sections 4.2 or 4.3, does not imply automatic approval for installation of the tested system on any building in the High-Velocity Hurricane Zone jurisdiction. The applicability of system installation shall be determined in one of the following two ways:

4.4.1 For exposure "C" buildings having a roof mean height less than or equal to 40 feet, the Uniform Building Permit applicant may utilize the procedures set forth in TAS 127 to determine whether or not a particular tile system may be installed on a particular building in the High-Velocity Hurricane Zone jurisdiction. The procedure outlined in Section 4.4.2 is also an option for those exposure "C" buildings having a roof mean height less than or equal to 40 feet.

4.4.2 The Chief Code Compliance Officer shall determine the acceptability of system installation based on results from engineering design calculations in compliance with RAS 127. These calculations shall be: 1) performed for all buildings having a roof mean height greater than 40 feet; 2) performed, signed and sealed by a Professional Engineer or Registered Architect; and, 3) shall take precedence over the procedures outlined in Section 4.4.1.

5. Apparatus

5.1 The test apparatus shall consist of a steel framework and loading bar of sufficient strength to remain rigid when loads of up to 250 lbf are applied. The frame shall be fixed to a solid floor so as to prevent movement and provide a solid reference level for deflection measurements. (See Figure 1, attached.)

5.2 The loading bar position shall be adjustable along the frame width to facilitate the upward loading of the "test tile." The opposite end of the loading bar shall be attached to a hydraulic jack, or other similarly controllable mechanical device. (See Figure 1, attached.)

5.3 Tile Load Transfer (See Figure 1, attached)

5.3.1 Moment based systems shall have the static uplift load applied at a point along the center of the tile, 0.76 x l (l = tile length) from the head of the tile.

5.3.2 Uplift based systems shall have the static uplift load applied at the center of the tile.

5.3.3 Prior to test specimen construction, install one of the following load transfer devices to the 'test tile' at the appropriate location, as noted in Section 5.3.1 or 5.3.2, above.

- Drill a hole at the appropriate location in the 'test tile' using a 0.203 in. - 0.205 in. nonpercussion, cutting carbide bit to minimize spaulling. Discard any tile which, subsequent to drilling, exhibits spaulling in excess of $^1/_4$ in. Install a $^1/_4$ in. diameter, threaded concrete anchor through the pre-drilled hole allowing for penetration not greater than $^1/_4$ in.

or,

- Drill a hole at the appropriate location in the "test tile" using a $^7/_{16}$ in. - $^1/_2$ in. nonpercussion, cutting carbide bit to minimize spaulling. Discard any tile which, subsequent to drilling, exhibits spaulling in excess of $^1/_4$ in. Cover the bottom of the predrilled hole with duct tape and fill the hole with epoxy. Insert a $^3/_8$ in. diameter epoxy bolt into the hole and allow to cure for 24 hours prior to tile installation.

5.4 A load cell, attached to or forming part of the loading bar, shall be rigidly attached to the load transfer device, noted in Section 5.3.3, to measure the load applied. The load cell shall have a digital, dial or chart recorded output capable of recording loads up to 250 lbf and a resolution of 0.5%. The load cell shall be capable of recording the ultimate load incurred upon the "test tile." (See Figure 1, attached.)

5.5 Linear displacement gauges (i.e. dial gauges) shall be used to record the 'test tile' displacement. Gauges shall be firmly attached to the plywood substrate adjacent to the "test tile." (See Figure 1, attached.)

5.6 A measurement device with an accuracy of 0.05 lbm shall be used to determine the average mass of the 'test tiles.'

6. Test Limitations and Precautions

6.1 During the test, all testing agency representatives and other test observers shall wear eye protection to prevent injury.

6.2 The Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

6.3 Care must be taken not to damage, twist or distort the test specimen during handling as this may affect the test specimen's performance.

7. Test Specimen - 14 test specimens shall be constructed in compliance with the specification herein. Prior to test specimen construction, refer to Section 9.1 herein.

7.1 Deck

7.1.1 The wood test deck shall consist of APA 32/16 span rated sheathing of $^{15}/_{32}$ in. thickness installed over 2 in. x 6 in. perimeter supports and 2 in. x 6 in. intermediate supports spaced 24 in. apart. The sheathing shall be attached with 8d common nails at 6 in. o.c. at panel edges and 12 in. o.c. at intermediate supports. The sheathing shall be sized to accommodate the tile installation specified in Section 7.6 while meeting the size constraints of the steel test frame. The test deck shall be capable of resisting a minimum dead load of 55 psf.

7.2 Underlayment

7.2.1 Underlayment shall be a standard 30/90 system with a 30 lb. ASTM D 226, Type II anchor sheet and an ASTM D 249 mineral surface roll roofing as the top ply.

7.2.2 The anchor sheet shall be mechanically attached to the wood sheathing with 12 ga. roofing nails and $^{15}/_{8}$ in. tin caps, in a 12 in. grid pattern staggered in two rows in the field and 6 in. o.c. attachment at any laps. The mineral surface top ply shall be applied in a full mopping of ASTM D 312, Type IV asphalt.

7.3 Mortar (if a mortar set tile system assembly)

7.3.1 Mortar mix shall have a roofing component Product Approval for use with the mortar set tile system and shall be in compliance with TAS 123.

7.3.2 Mortar shall be mixed using the mixing ratio specified in the mortar manufacturer's Product Approval.

7.3.3 Mortar flow shall be determined using a cone penetrometer test, in compliance with ASTM C 780 (Appendix A1), the results of which shall be $2^1/_8 \pm {}^1/_8$ in. (55 ± 3 mm) of penetration.

7.4 Adhesive (if an adhesive set tile system assembly)

7.4.1 Adhesive shall have a Roofing Component Product Approval for use with the adhesive set tile system which is being tested and shall be applied in compliance with the provisions set forth in that Approval.

7.5 Supplemental Adhesive (Optional)

7.5.1 The applicant may use a "dab" of adhesive applied to the underside of each "test tile" for additional component securement. The adhesive shall have a Roofing Component Product Approval for use with tile systems.

7.5.2 The tile adhesive shall be applied at the "test tile" headlap in a single $^3/_8$ in. wide x $1^1/_4$ in. long bead placed between $1^1/_2$ in. and 2 in. from the nose of the "test tile."

7.6 Tile

7.6.1 Tile shall have an identifiable mark confirming the manufacturer and shall be identified as a flat, low or high profile tile.

7.6.2 Mortar set tile shall be applied in a bed of mortar, the amount of which shall be a 10 in. trowel filled with mortar which is in compliance with Section 7.3 of this Protocol. The 10 in. trowel of mortar shall be placed at the same location beneath each tile for every test specimen constructed. This locations shall be noted in the final report.

7.6.3 Adhesive set tile shall be applied in the quantity of adhesive specified on the adhesive manufacturer's roofing component Product Approval.

7.6.4 All tile shall be applied with a minimum 3 in. head lap.

7.6.5 The first course shall consist of two tiles installed at the lower edge of the test deck. The second course shall consist of the 'test tile' installed over the first course, insuring for a minimum 3 in. headlap. Tile in the first course which are not tested shall be installed to insure the "test tile," in the second course, is at the correct angle relative to the sheathing.

7.7 During test specimen construction, measure and record the "test tile angle" (a); the angle between the bottom surface of the "test tile"and the substrate. Record this angle for each of the 14 test specimens and determine an average "test tile angle."

7.8 The test specimen shall be inspected by a Professional Engineer or Registered Roof Consultant who shall certify, in the final test report, that it was constructed in compliance with the provisions of this Protocol.

8. Conditioning

8.1 Conditioning shall consist of 21 days at outdoor ambient conditions in which the relative humidity reaches not less that 80% ± 10% during not less than 5 of the 21 days and the surface temperature of the test panel reaches 120 ± 5°F for not less 4 hours during 10 of the 21 days.

8.1.1 The surface temperature shall be measured with a surface mounted thermocouple and recorded on a chart recorder to confirm that the surface temperature meets the criteria noted in Section 8.1

8.2 If the outdoor ambient conditions do not meet the requirements set forth in Section 8.1 during the 21 day conditioning period, additional conditioning time shall be incurred until these requirements are met.

8.3 If the outdoor ambient condition requirements set forth in Section 8.1 cannot be achieved, conditioning shall consist of 336 hours (14 days) of which the first 120 hours (5 days) shall be in a controlled environment and the remaining 216 hours (9 days) shall be at outdoor ambient conditions.

8.3.1 The first phase of conditioning shall consist of 120 hours (5 days) during which the relative humidity is held at a constant 80% ± 10% and the following surface temperature increments and decrements are attained. Each specified surface temperatures shall be sustained for not less than one continuous hour.

Time Frame (Hour Number)		Peak Surface Temperature (°F)
Starting Hour	Ending Hour	
0	12	75 + 5
12	24	120 + 5
24	36	75 + 5
36	48	120 + 5
48	60	75 + 5
60	72	120 + 5
72	84	75 + 5
84	96	120 + 5
96	108	75 + 5
108	120	120 + 55

The temperature increase rate shall not exceed 10°F per hour.

8.3.2 The surface temperature shall be measured with a surface mounted thermocouple and recorded on a chart recorder to confirm that the surface temperature meets the criteria noted in Section 8.3.1.

8.3.3 Subsequent to the end of 120 hours, the test specimen shall be allowed to sit in outdoor ambient conditions for the remaining 216 hours (9 days).

8.4 Care must be taken not to damage, twist or distort the test specimen during handling. Such damage may adversely affect the bond's performance.

9. Procedure

9.1 Prior to installing the "test tiles" on the test specimen, determine the mass of the 14 "test tiles" to an accuracy of 0.05 lbm, tabulate the data and determine the average mass.

9.2 After test specimen conditioning is complete, mount one of the 14 test specimens on the test apparatus at the predetermined test slope (θ), as noted in Section 1.2.

9.3 Position the displacement device at the nose of the "test tile" to measure the displacement in the direction of the applied load.

9.4 Connect the loading and load measurement devices rigidly to the load transfer device, noted in Section 5.3.3, and apply an uplift load. Care shall be taken to ensure that the uplift load is applied vertically and that the tile's displacement rate does not exceed 2 in. per minute.

9.5 An observer shall monitor the tile, the mortar or adhesive bonds and the displacement gauges while a second observer monitors the load measuring device. Record the ultimate load at which: 1) the tile breaks or cracks; 2) the mortar patty or adhesive delaminates from the underlayment; 3) the tile delaminates from the mortar patty or adhesive; or, 4) the nose of the tile displaces vertically 2 in.

9.6 Repeat Sections 9.2 through 9.5 for each of the remaining test specimens and tabulate the ultimate uplift loads.

10. Calculations

10.1 Weight (W)

10.1.1 Determine the average weight of the 14 'test tiles' using the average mass of these tiles, determined in Section 9.1, and the following equation.

$$W = mx \times \frac{1\,slug}{32.174\,lbm} \times g$$

where,

W = average tile weight (lbf);
m = average tile mass (lbm); and,
g = 32.2 ft/s^2 = acceleration of gravity constant.

Note: 1 slug = 1 lbf s^2/ ft

10.2 Restoring Moment due to Gravity (M_g)

NOTE: This calculation need only be performed for moment based systems.

10.2.1 Determine the restoring moment due to gravity (M_g) at the test slope (θ) using the tile's average weight (W), determined in Section 10.1, the "test tile angle" (α), determined in Section 7.7, and the following equation.

$$M_g = W \text{ x } \cos(\theta - \alpha) \text{ x } L_g$$

where,

M_g = restoring moment due to gravity (ft-lbf);
W = tile's average weight (lbf);
L_g = tile's gravitational moment arm (ft);
θ = test slope (degrees); and,
α = 'test tile angle' (degrees)

Notes:

1. The tile's gravitational moment arm (L_g) is the orthogonal distance from the

tile's center of gravity to its axis of rotation.

2. For S shaped clay or concrete tile, the axis of rotation is located toward the upper left corner of the tile. A gravitational moment arm of $L_g = 0.728$ feet has been found to be typical of this type of tile. The testing agency shall confirm this value through measurement prior to use in the above noted equation.

3. For all other tile, $L_g = (0.5 \times l)$ where l = tile length

10.3 Statistical Analysis of Test Data

10.3.1 From the 14 recorded ultimate loads, eliminate the high and low values leaving 12 ultimate load values for statistical analysis.

10.3.2 Determine the mean ultimate load (F) and the standard deviation (S_F) using the tabulated data and the following equations.

$$\overline{F} = \frac{1}{12}\sum_{i=1}^{12} F_i \qquad \text{and,}$$

$$S_F = \sqrt{\frac{1}{11}\sum_{i=1}^{12}\left(F_i - \overline{F}\right)^2} \qquad \text{where,}$$

$\overline{F}$ = mean ultimate load;

S_F = standard deviation;

F = recorded ultimate load; and,

i = 1, 2, ... , 12 = test number.

10.3.3 Determine the percent deviation from the mean (S'_F) using the information from Section 10.3.21 and the following equation.

where,

$$S'_F = \left(\frac{S_F}{F}\right) \times 100$$

S'_F = percent deviation from the mean (%);

S_F = standard deviation; and,

$\overline{F}$ = mean ultimate load.

10.3.3.1 If the percent deviation from the mean (S'_F) is greater than or equal to 20%, then the test results shall be considered null and void and the test shall be considered a re-test.

10.4 Minimum Characteristic Resistance Load (F')

10.4.1 Determine the minimum characteristic resistance load (F') using the mean ultimate load (F) and the following equation.

$$F' = \left(\frac{\overline{F} - W}{MS}\right) \qquad \text{where,}$$

F' = minimum characteristic resistance load;

$\overline{F}$ = mean ultimate load;

MS = margin of safety = 2; and,

W = average weight.

NOTE: The requirement noted in Section 10.3.3.1 shall be met prior to determining the minimum characteristic resistance load (F').

10.5 Attachment Resistance Expressed as a Moment (M_f)

NOTE: This calculation need only be performed for moment based systems.

10.5.1 Determine the attachment resistance expressed as a moment (M_f) provided by the tile's bond at test slope (θ) using the minimum characteristic resistance load (F'), determined in Section 10.4.1, the 'test tile angle' (α), determined in Section 7.7, and the following equation.

$M_f = [F' \times \cos(\theta - \alpha) \times L_f]$ where,

M_f = attachment resistance (ft-lbf);

F' = minimum characteristic resistance load (lbf);

L_f = tile's attachment moment arm (ft);

θ = test slope (degrees); and,

α = test tile angle (degrees).

NOTES:

1. The tile's attachment moment arm (L_f) is the orthogonal distance from the point of load application to its axis of rotation.

2. For all tile other than S-shaped clay or concrete tile:

   $L_f = (0.76 \times l)$ where, l = tile length

3. For S- shaped clay or concrete tile, the axis of rotation is located toward the upper left corner of the tile. For this reason the tile's attachment moment arm (L_f) shall be measured for the S shaped clay or concrete tile in question. Measure the orthogonal distance from the point of load application (as noted in Section 5.3.1) to the axis of rotation. This distance is the tile's attachment moment arm (L_f).

11. Report

11.1 The final test report shall include the following:

11.1.1 A description and sketch of the mortar or adhesive set tile, including the manufacturer and type of tile (i.e., flat or high profile).

11.1.2 A statement of which load transfer device, noted in Section 5.3, was utilized and which test slope (θ) was selected by the manufacturer.

11.1.3 A detailed report of the method of test specimen construction, including a photograph of the test specimen and certification by a Professional Engineer or Registered Roof Consultant that the test specimen was constructed in compliance with the specifications of this Protocol.

11.1.4 Recorded surface temperature results confirming compliance with the conditioning requirements set forth in Section 8.

11.1.5 Tabulated results of mass measurements of the 14 'test tiles' and an average mass.

11.1.6 Tabulated 'test tile angle' (α) measurements for the 14 test specimens and an average 'test tile angle.'

11.1.7 Tabulated ultimate load measurements (F1, F2, F3, . . . F12) for the 14 test specimens.

11.1.8 Average tile weight (W) calculations and results.

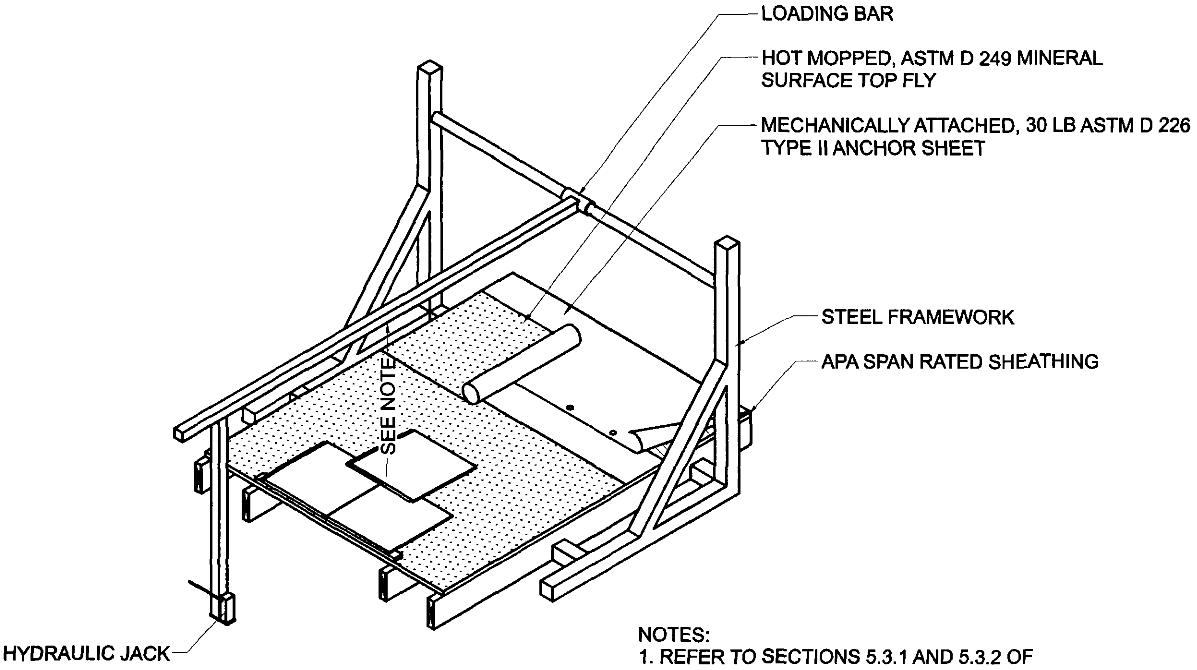
11.1.9 Restoring moment due to gravity (M_g) calculations and results (needed only for moment based systems).

11.1.10 Calculations and results confirming the percent deviation from the mean (S'_F) less than 20%.

11.1.11 Minimum characteristic resistance load (F') calculations and results.

11.1.12 Attachment resistance expressed as a moment (M_f) calculations and results (needed only for moment based systems).

11.1.13 A video tape of all pertinent aspects of the test, including test specimen construction and uplift load application.


LOADING BAR
HOT MOPPED, ASTM D 249 MINERAL SURFACE TOP FLY
MECHANICALLY ATTACHED, 30 LB ASTM D 226 TYPE II ANCHOR SHEET
STEEL FRAMEWORK
APA SPAN RATED SHEATHING
SEE NOTE
HYDRAULIC JACK

NOTES:

1. REFER TO SECTIONS 5.3.1 AND 5.3.2 OF THIS PROTOCOL FOR THE POINT OF LOAD APPLICATION

FOR MOMENT BASED SYSTEM: POINT = 0.76 x LENGTH

FOR MOMENT UPLIFT SYSTEM: POINT = CENTER OF COMPONENT

FIGURE 1
STATIC UPLIFT APPARATUS

ROOFING APPLICATION STANDARD (TAS) No. 102-95

TEST PROCEDURE FOR STATIC UPLIFT RESISTANCE OF MECHANICALLY ATTACHED, RIGID ROOF SYSTEMS [For Mechanically Attached, Rigid Roof Systems Accompanied by a Clip, Refer to TAS 102(A)]

1. Scope

1.1 This Protocol covers the determination of: 1) the average weight (W) of a rigid component; 2) the restoring moment due to gravity (M_g) provided by the component's weight; 3) the minimum characteristic resistance load (F′); and, 4) the attachment resistance expressed as a moment (M_f) provided by the mechanical attachment of the component.

1.2 The test procedures outlined herein shall be used to determine: 1) the average mass (m) of a rigid component; and, 2) the resistance to an uplift load placed on a mechanically attached rigid component installed on a test specimen which is set at a predetermined test slope (θ).

The point of application of the uplift load shall be dependent upon whether the system has been or is to be tested for wind characteristics in compliance with TAS 108.

Prior to conducting the testing, the system manufacturer shall specify to the testing agency a test slope (θ) of either 9.5° (2 in:12 in.) or 18.5° (4 in:12 in.).

NOTES:

1. The *Florida Building Code, Building* requires a 'Counter-Batten' application for nail-on tiles installed on slopes 2 in:12 in. to < 4 in:12 in. See RAS 118.
2. The *Florida Building Code, Building* requires a 'Horizontal Batten' application for nail-on tiles installed on slopes greater than 7 in:12 in. See RAS 119.

1.3 The calculations outlined herein shall be used to determine: 1) the average weight (W) of the rigid component; 2) the restoring moment due to gravity (M_g), determined from knowledge of the component's average weight (W) and dimension, and the test slope (θ); 3) the minimum characteristic resistance load (F′) which is representative of the test data noted in Section 1.2; and, 4) the attachment resistance expressed as a moment (M_f) provided by the tile's method of attachment at the test slope (θ).

1.4 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a Professional Engineer or Registered Roof Consultant.

1.5 A safety factor of 2:1 shall be applied to test results, as noted in Section 9.4.1.

2. Referenced Documents

2.1 *The Florida Building Code, Building.*

2.2 *Application Standards*

TAS 108 Test Procedure for Wind Tunnel Testing of Air Permeable, Rigid, Discontinuous Roof Systems

RAS 127 Standard Procedure of Determining Applicability of Tile System Installation

2.3 *Application Standards*

RAS 118 Installation of Mechanically Fastened Roof Tile Systems. System two: Direct Deck and Counter Battens only.

RAS 119 Installation of Mechanically Fastened Roof Tile Systems. System one:Direct Deck and Horizontal Battens only.

2.4 *The American Plywood Association* Performance Standards and Polices for Structural-Use Panels

2.5 *Redland Technologies - New Technology & Product Development Centre*
Fixing Studies for MRTI Normal Weight Tiles - SBCCI Submission

2.6 *The American Society of Civil Engineers (ASCE)*
ASCE 7; Minimum Design Loads for Buildings and Other Structures

2.7 *ASTM Standards*:

E 380 Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.8 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units

3.1 Definitions - for definitions of terms in this Protocol, refer to Chapters 2 and 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* and/or Fixing Studies for MRTI Normal Weight Tiles; and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use

4.1 The test procedures and calculations specified herein provide a means for establishing: 1) the average weight (W) of the rigid component; 2) the restoring moment due to gravity (M_g) provided by the component's weight; 3) the minimum characteristic resistance load (F'); and, 4) the attachment resistance expressed as a moment (M_f) provided by the mechanical attachment.

The component's average weight (W) is a measure of its gravitational force of attraction to the earth's surface. Sea level conditions are assumed for the purposes of this Protocol.

The component's restoring moment due to gravity (M_g) is a measure of its ability to resist a rotational force (moment) prior to its attachment to the substrate, when positioned at the specified test slope (θ). It represents the component's weight in terms of resisting a rotational force.

The minimum characteristic resistance load (F′) represents the combined effects of the component's weight and its attachment to the substrate in their ability to resist an uplift load placed at a predetermined location on the component.

The attachment resistance expressed as a moment (M_f) is a measure of the attachment's ability to resist the rotational force incurred upon it due to the uplift load placed on the component.

4.2 Systems which are also tested for wind characteristics (henceforth 'moment based systems'), in compliance with TAS 108, shall have: 1) the restoring moment due to gravity (M_g); 2) the minimum characteristic resistance load (F′); and, 3) the attachment resistance expressed as a moment (M_f), determined under this Protocol, listed in the system manufacturer's Product Approval for reference. These values are used, in conjunction with the system's aerodynamic multiplier (l), also listed in the Product Approval, in the calculations and procedures outlined in RAS 127 to determine the acceptable method(s) of attachment for system installation on a particular building in the High Velocity Hurricane Zone jurisdiction. While the calculations and procedures set forth in RAS 127 may be conducted by the Uniform Building Permit applicant, where the pressures (P) have been determined based on Table 1 and do not require additional signed and sealed engineering design calculations. All other calculations shall be conducted by a Professional Engineer or Registered Architect.

4.3 Systems which are not tested for wind characteristics (henceforth 'uplift based systems'), due to size constraints, air impermeability, or manufacturer decision, shall have: 1) the component's average weight (W); and, 2) the minimum characteristic resistance load (F′) listed in the system manufacturer's Product Approval for reference. These values are used in the calculations and procedures outlined in RAS 127 to determine the acceptable method(s) of attachment for system installation on a particular building in the High-Velocity Hurricane Zone jurisdiction. While the calculations and procedures set forth in RAS 127 may be conducted by the Uniform Building Permit applicant, where the pressures (P) have been determined based on Table 1 and do not require additional signed and sealed engineering design calculations. All other calculations shall be conducted by a Professional Engineer or Registered Architect.

NOTE: Uplift based systems need only be tested for average weight (W) and minimum characteristic resistance load (F′) in this Protocol.

4.4 Testing in compliance with this Protocol and subsequent listing of the results in the system manufacturer's Product Approval, as noted in Sections 4.2 or 4.3, does not imply automatic approval for installation of the tested system on any building in the High-Velocity Hurricane Zone jurisdiction. The applicability of system installation shall be determined in one of the following two ways:

4.4.1 For exposure 'C' buildings having a roof mean height less than or equal to 40 feet, the Uniform Building Permit applicant may utilize the procedures set forth in RAS 127 to determine acceptable methods of attachment. The procedure outlined in Section 4.4.2 is also an option for those exposure 'C' buildings having a roof mean height less than or equal to 40 feet.

4.4.2 The Chief Code Compliance Officer shall determine the acceptability of system installation based on results from engineering design calculations in compliance with RAS 127. These calculations shall be: 1) performed for all buildings having a roof mean height greater than 40 feet; 2) performed, signed and sealed by a Professional Engineer or a Registered Architect; and, 3) shall take precedence over the procedures outlined in Section 4.4.1.

5. Apparatus

5.1 The test apparatus shall consist of a steel framework and loading bar constructed of sufficient strength to remain rigid when loads of up to 250 lbf are applied. The frame shall be fixed to a solid floor so as to prevent movement and provide a solid reference level for deflection measurements. (See Figure 1, attached.)

5.2 The loading bar position shall be adjustable along the frame width to facilitate the upward loading of the 'test component.' The opposite end of the loading bar shall be attached to a hydraulic jack, or other similarly controllable mechanical device. (See Figure 1, attached.)

5.3 Component Load Transfer (See Figure 1, attached)

5.3.1 Moment based systems shall have the static uplift load applied at a point along the center of the component, 0.76 x l (l = component length) from the head of the component.

5.3.2 Uplift based systems shall have the static uplift load applied at the center of the component.

5.3.3 Prior to test specimen construction, install one of the following load transfer devices to the 'test component' at the appropriate location, as noted in Section 5.3.1 or 5.3.2, above.

- Drill a hole at the appropriate location in the 'test component' using a 0.203 in. - 0.205 in. nonpercussion, cutting carbide bit to minimize spalling. Discard any component which, subsequent to drilling, exhibits spalling in excess of $^1/_4$ in. Install a $^1/_4$ in. diameter, threaded concrete anchor through the pre-drilled hole allowing for penetration not greater than $^1/_4$ in.
- Drill a hole at the appropriate location in the 'test component' using a $^7/_{16}$ in. - $^1/_4$ in. non-percussion, cutting car-

bide bit to minimize spalling. Discard any component which, subsequent to drilling, exhibits spalling in excess of $^1/_4$ in. Cover the bottom of the pre-drilled hole with duct tape and fill the hole with epoxy. Insert a $^3/_8$ in. diameter epoxy bolt into the hole and allow to cure for 24 hours prior to component installation.

5.4 A load cell, attached to or forming part of the loading bar, shall be rigidly attached to the load transfer device, noted in Section 5.3.3, to measure the load applied. The load cell shall have a digital, dial or chart recorded output capable of recording loads up to 250 lbf and a resolution of 0.5%. The load cell shall be capable of recording the ultimate load incurred upon the 'test component.' (See Figure 1, attached.)

5.5 Linear displacement gauges (i.e., dial gauges) shall be used to record the 'test component' and/or fastener displacement. Gauges shall be firmly fixed to the plywood substrate adjacent to the "test component." (See Figure 1, attached.)

5.6 A measurement device with an accuracy of 0.05 lbm shall be used to determine the average mass of the "test components."

6. Test Limitations and Precautions

6.1 During the test, all testing agency representatives and other test observers shall wear eye protection to prevent injury.

6.2 The Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

6.3 Care must be taken not to damage, twist or distort the test specimen during handling as this may affect the test specimen's performance.

7. Test Specimen

Test Specimen - 14 test specimens shall be constructed in compliance with the specification herein. **Prior to test specimen construction, refer to Section 8.1 herein.**

7.1 Deck

7.1.1 The wood test deck shall consist of APA 32/16 span rated sheathing of $^{15}/_{32}$ in. thickness installed over 2 in. x 6 in. perimeter supports and 2 in. x 6 in. intermediate supports spaced 24 in. apart. The sheathing shall be attached with 8d common nails at 6 in. o.c. at panel edges and 12 in. o.c. at intermediate supports. The sheathing shall be sized to accommodate the component installation specified in Section 7.6 while meeting the size constraints of the steel test frame. The test deck shall be capable of resisting a minimum dead load of 55 psf.

7.2 Underlayment

7.2.1 Underlayment shall be a standard 30/90 system with a 30 lb ASTM D 226, type II anchor sheet and an ASTM D 249 mineral surface roll roofing as the top ply.

7.2.2 The anchor sheet shall be mechanically attached to the wood sheathing, with 12 ga. roofing nails and $1^5/_8$ in. tin caps, in a 12 in. grid pattern staggered in two rows in the field and 6 in. o.c. attachment at any laps. The mineral surface top ply shall be applied in a full mopping of ASTM D 312, type IV asphalt.

7.3 Fasteners

7.3.1 Component attachment fasteners (i.e. nails, screws, tile straps, etc.) shall be those recommended in the system manufacturer's published installation instructions. Nails shall be not less than 0.109 in. in diameter and minimum screws shall be #8 diameter screw fasteners. Component attachment fasteners shall meet the corrosion requirements set forth in TAS 114, Appendix "E."

7.4 Battens (if applicable)

7.4.1 Horizontal Batten System

- Horizontal battens shall be of nominal 1 in. x 2 in. dimensional lumber and shall be spaced to provide a minimum 3 in. head lap, or to match the interlocking configuration of the component's profile.
- Horizontal battens shall be nailed to the wood test deck at 6 in. o.c. using 12 ga. roofing nails.

7.4.2 Counter Batten System

- Vertical battens shall be of nominal 1 in. x 4 in. lumber and shall be spaced 24 in. over the intermediate supports (trusses).
- Vertical battens shall be nailed to the wood test deck at 6 in. o.c. using 12 ga. roofing nails.
- Horizontal battens (counter battens) shall be as noted in Section 7.4.1, nailed to the 1 in. x 4 in. vertical battens using 12 ga. roofing nails of sufficient length to penetrate both battens.

7.5 Supplemental Adhesive (Optional)

7.5.1 The applicant may use a 'dab' of adhesive applied to the underside of each 'test tile' for additional component securement. The adhesive shall have a Roofing Component Product Approval for use with tile systems.

7.5.2 The tile adhesive shall be applied at the 'test tile' headlap in a single $^3/_8$ in. wide x $1^1/_4$ in. long bead placed between $1^1/_2$ in. and 2 in. from the nose of the "test tile."

7.6 Rigid Components

7.6.1 The type of mechanically attached, rigid roof system shall be identified and the system's rigid components shall have an identifiable mark, confirming the system manufacturer.

7.6.2 Each component shall be installed in compliance with the system manufacturer's published installation instructions; the current Product Approval; and/or the minimum requirements set forth in Chapter 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*. The requirements of the *Florida Building Code, Building* shall take precedence.

7.6.3 The first course shall consist of two components installed at the lower edge of the test deck, either directly to the deck or over battens. The second course shall consist of the 'test component' installed over the first course, either directly to the deck or over battens, insuring for a minimum 3 in. head lap. Components in the first course, which are not tested, shall be installed to insure the "test component," in the second course, is at the correct angle relative to the sheathing. (See Figure 1, attached.)

7.7 During test specimen construction, measure and record the 'test component angle' (α); the angle between the bottom surface of the 'test component' and the substrate. Record this angle for each of the 14 test specimens and determine an average "test component angle."

7.8 The test specimen shall be inspected by a Professional Engineer or Registered Roof Consultant who shall certify, in the final test report, that it was constructed in compliance with the provisions of this Protocol.

8. Procedure

8.1 Prior to installing the 'test components' on the test specimens, determine the mass of the 14 'test components' to an accuracy of 0.05 lbm, tabulate the data and determine the average mass.

8.2 Mount one of the 14 test specimens on the test apparatus at the predetermined test slope (θ), as noted in Section 1.2.

8.3 Position the displacement devices to measure displacement in the direction of the applied load. Position one device at the nose of the "test component." For 'S' shaped clay or concrete tile, position an additional device at the fastener point in the valley of the "test tile."

8.4 Connect the loading and load measurement devices rigidly to the load transfer device, noted in Section 5.3.3, and apply an uplift load. Care shall be taken to ensure that the uplift load is applied vertically and that the 'test component's' displacement rate does not exceed 2 in. per minute.

8.5 An observer shall monitor the component, its attachment point(s) and the displacement gauge(s) while a second observer monitors the load measuring device. Record the ultimate load at which: 1) the 'test component' or fastener breaks or cracks; 2) the nose of the 'test component' vertically displaces 2 in.; or 3) for 'S' shaped clay or concrete tile only, the fastener displaces vertically $^1/_4$ in.

8.6 Repeat Sections 8.2 through 8.5 for each of the remaining test specimens and tabulate the ultimate uplift loads.

9. Calculations

9.1 Weight (W)

9.1.1 Determine the average weight of the 14 'test components' using the average mass of these components, determined in Section 8.1, and the following equation.

$$W = m \times \frac{1\ slug}{32.174\ lbm} \times g$$ where,

W = average component weight (lbf);

m = average component mass (lbm); and,

g = 32.2 ft/s^2 = acceleration of gravity constant.

NOTE: 1 slug = 1 lbf s^2/ ft

9.2 Restoring Moment due to Gravity (M_g)

NOTE: This calculation need only be performed for moment based systems.

9.2.1 Determine the restoring moment due to gravity (M_g) at the test slope (θ) using the component's average weight (W), determined in Section 9.1, the 'test component angle' (α), determined in Section 7.7, and the following equation.

$$M_g = W \times \cos(\theta - \alpha) \times L_g$$

where,

M_g = restoring moment due to gravity (ft-lbf);

W = component's average weight (lbf);

L_g = component's gravitational moment arm (ft);

θ = test slope (degrees); and,

α = 'test component angle' (degrees)

NOTES:

1. The component's gravitational moment arm (L_g) is the orthogonal distance from the component's center of gravity to its axis of rotation.

2. For 'S' shaped clay or concrete tile, the axis of rotation is located toward the upper left corner of the tile. For such tile attached directly to the deck, a gravitational moment arm of L_g = 0.728 feet has been found to be typical. For such tile attached through battens, a gravitational moment arm of L_g = 0.679 feet has been found to be typical. The testing agency shall confirm these values through measurement prior to use in the above noted equation.

3. For all other components attached directly to the deck:

   L_g = (0.5 x l) where,

   l = component length.

4. For all other components attached through battens:

   L_g = (0.5 x l) - y where,

   l = component length; and,

y = distance from head of component to center line of horizontal batten.

9.3 Statistical Analysis of Test Data

9.3.1 From the 14 recorded ultimate loads, eliminate the 'high' and 'low' values leaving 12 ultimate load values for statistical analysis.

9.3.2 Determine the mean ultimate load (F) and the standard deviation (S_F) using the tabulated data from Section 8 and the following equations.

$$\overline{F} = \frac{1}{12}\sum_{i=1}^{12} F_i \qquad \text{and,}$$

$$S_F = \sqrt{\frac{1}{11}\sum_{i=1}^{12}\left(F_i - \overline{F}\right)^2}$$

$\overline{F}$ = average ultimate load (lbf);

S_F = standard deviation;

F = recorded ultimate load; and,

i = 1, 2, 3, . . . , 12 = test number.

9.3.3 Determine the percent deviation from the mean (S'_F) using information from Section 9.3.2 and the following equation.

$$S'_F = \left(\frac{S_F}{\text{F}}\right) \times 100 \qquad \text{where,}$$

S'_F = percent deviation from the mean (%);

S_F = standard deviation; and,

F = mean ultimate load.

9.3.3.1 If the percent deviation from the mean (S'_F) is greater than or equal to 20%, then the test results shall be considered null and void and the test shall be considered a re-test.

9.4 Minimum Characteristic Resistance Load (F')

9.4.1 Determine the minimum characteristic resistance load (F') using the mean ultimate load (F) and the following equation.

$$F' = \left(\frac{\overline{F} - W}{MS}\right) \qquad \text{where,}$$

F' = minimum characteristic resistance load;

$\overline{F}$ = mean ultimate load;

MS = margin of safety = 2; and,

W = average weight.

NOTE: The requirement noted in Section 9.3.3.1 shall be met prior to determining the minimum characteristic resistance load (F').

9.5 Attachment Resistance Expressed as a Moment (M_f)

NOTE: This calculation need only be performed for moment based systems.

9.5.1 Determine the attachment resistance expressed as a moment (M_f) provided by the component's attachment at test slope (q) using the minimum characteristic resistance load (F'), determined in Section 9.4.1, the 'test tile angle' (α), determined in Section 7.7, and the following equation.

$$M_f = [\text{F}' \text{ x } \cos(\theta - \alpha) \text{ x } \text{L}_f] \qquad \text{where,}$$

M_f = attachment resistance (ft-lbf);

F' = minimum characteristic resistance load (lbf);

L_f = tile's attachment moment arm (ft);

θ = test slope (degrees); and,

α = test tile angle (degrees).

NOTES:

1. The component's attachment moment arm (L_f) is the orthogonal distance from the point of load application to its axis of rotation.
2. Components Other Than 'S' Shaped Clay or Concrete Tile:

   Direct deck:

   L_f = (0.76 x l) where,

   l = component length.

Over battens:

L_f = (0.76 x l) - y where,

l = component length; and,

y = distance from head of component to centerline of horizontal batten

3. 'S' Shaped Clay or Concrete Tile: For'S' shaped clay or concrete tile, the axis of rotation is located toward the upper left corner of the tile. For this reason the tile's attachment moment arm (L_f) shall be measured for the tile in question, either installed directly to the deck or over battens. Measure the orthogonal distance from the point of load application (as noted in Section 5.3.1) to the axis of rotation. This distance is the tile's attachment moment arm (L_f).

10. Report

10.1 The final test report shall include the following:

10.1.1 A description and sketch of the rigid component designed for use in the mechanically attached, rigid roof system, including the manufacturer and type of component.

10.1.2 A statement of which load transfer device, noted in Section 5.3, was utilized and which test slope (θ) was selected by the manufacturer.

10.1.3 A detailed report of the method of test specimen construction, including a photograph of the test specimen and certification by a Professional Engineer or Registered Roof Consultant that the test specimen was constructed in compliance with the specifications of the Protocol.

10.1.4 Tabulated results of mass measurements of the 14 'test components' and an average mass.

10.1.5 Tabulated "test component angle" (α) measurements for the 14 test specimens and an average "test component angle."

10.1.6 Tabulated ultimate load measurements (F1, F2, F3, . . . F12) for the 14 test specimens.

10.1.7 Average component weight (W) calculations and results.

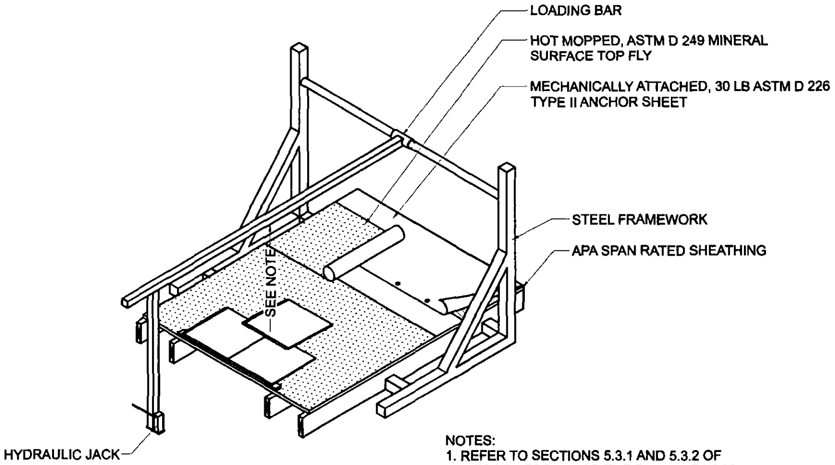
10.1.8 Restoring moment due to gravity (M_g) calculations and results (needed only for moment based systems).

10.1.9 Calculations and results confirming the percent deviation from the mean (S'_F) less than 20%.

10.1.10 Minimum characteristic resistance load (F′) calculations and results.

10.1.11 Attachment resistance expressed as a moment (M_g) calculations and results (needed only for moment based systems).

10.1.12 A video tape of all pertinent aspects of the test, including test specimen construction and uplift load applications.


LOADING BAR
HOT MOPPED, ASTM D 249 MINERAL SURFACE TOP FLY
MECHANICALLY ATTACHED, 30 LB ASTM D 226 TYPE II ANCHOR SHEET
STEEL FRAMEWORK
APA SPAN RATED SHEATHING
SEE NOTE
HYDRAULIC JACK

NOTES:
1. REFER TO SECTIONS 5.3.1 AND 5.3.2 OF THIS PROTOCOL FOR THE POINT OF LOAD APPLICATION

FOR MOMENT BASED SYSTEM: POINT = 0.76 x LENGTH

FOR MOMENT UPLIFT SYSTEM: POINT = CENTER OF COMPONENT

FIGURE 1
STATIC UPLIFT TEST APPARATUS

ROOFING APPLICATION STANDARD (TAS) No. 102(A)-95

TEST PROCEDURE FOR STATIC UPLIFT RESISTANCE OF MECHANICALLY ATTACHED, CLIPPED, RIGID, ROOF SYSTEMS

(For Methods of Mechanical Attachment Excluding Clips, Refer to TAS 102)

1. Scope

1.1 This Protocol covers the determination of: 1) the average weight (W) of a rigid component; 2) the restoring moment due to gravity (M_g) provided by the component's weight; 3) the minimum characteristic resistance load (F′); and, 4) the attachment resistance expressed as a moment (M_f) provided by the mechanical attachment and clipped attachment of the component.

1.2 The test procedures outlined herein shall be used to determine: 1) the average mass (m) of a rigid component; and, 2) the resistance to an uplift load placed on a clipped rigid component installed on a test specimen which is set at a predetermined test slope (θ).

The point of application of the uplift load shall be dependent upon whether the system has been or is to be tested for wind characteristics in compliance with TAS 108. (See Section 5.3, herein.)

Prior to conducting the testing, the system manufacturer shall specify to the testing agency a test slope (θ) of either 9.5° (2 in:12 in.) or 18.5° (4 in:12 in.).

NOTES:

1. The *Florida Building Code, Building* requires a 'Counter-Batten' application for nail-on tiles installed on slopes 2 in.:12 in. to < 4 in:12 in. See RAS 118.
2. The *Florida Building Code, Building* requires a Horizontal Batten application for nail-on tiles installed on slopes greater than 7 in:12 in. See RAS 119.

1.3 The calculations outlined herein shall be used to determine: 1) the average weight (W) of the rigid component; 2) the restoring moment due to gravity (M_g), determined from knowledge of the component's average weight (W) and dimension, and the test slope (θ); 3) the minimum characteristic resistance load (F′) which is representative of the test data noted in Section 1.2; and, 4) the attachment resistance expressed as a moment (M_f) provided by the tile's method of attachment at the test slope (θ).

1.4 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a Professional Engineer or Registered Roof Consultant.

1.5 A safety factor of 2:1 shall be applied to test results, as noted in Section 9.4.1.

2. Referenced Documents

2.1 *The Florida Building Code, Building.*

2.2 *Application Standards*

TAS 108 Test Procedure for Wind Tunnel Testing of Air Permeable, Rigid, Discontinuous Roof Systems

RAS 127 Standard Procedure of Determining Applicability of Tile System Installation.

2.3 *Application Standards*

RAS 118 System #2: Installation of Mechanically Fastened Roof Tile Systems Counter Batten and Direct Deck only.

RAS 119 System #1: Installation of Mechanically Fastened Roof Tile Systems. Direct Deck and Horizontal Batten only. Horizontal Batten Applications only.

2.4 *The American Plywood Association*
Performance Standards and Polices for Structural-Use Panels

2.5 *Redland Technologies - New Technology & Product Development Centre*
Fixing Studies for MRTI Normal Weight Tiles - SBCCI Submission

2.6 *The American Society of Civil Engineers (ASCE)*
ASCE 7; Minimum Design Loads for Buildings and Other Structures

2.7 *ASTM Standards:*

E 380 Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.8 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units

3.1 *Definitions* - for definitions of terms in this Protocol, refer to Chapters 2 and 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*; and/or Fixing Studies for MRTI Normal Weight Tiles; and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use

4.1 The test procedures and calculations specified herein provide a means for establishing: 1) the average weight (W) of the rigid component; 2) the restoring moment due to gravity (M_g) provided by the component's weight; 3) the minimum characteristic resistance load (F′); and, 4) the attachment resistance expressed as a moment (M_f) provided by the mechanical and clipped attachment.

The component's average weight (W) is a measure of its gravitational force of attraction to the earth's surface. Sea level conditions are assumed for the purposes of this Protocol.

The component's restoring moment due to gravity (M_g) is a measure of its ability to resist a rotational force (moment) prior to its attachment to the substrate, when positioned at the specified test slope (θ). It represents the component's weight in terms of resisting a rotational force.

The minimum characteristic resistance load (F′) represents the combined effects of the component's weight and its clipped attachment to the substrate in their ability to resist an uplift load placed at a predetermined location on the component.

The attachment resistance expressed as a moment (M_f) is a measure of the clipped attachment's ability to resist the rotational force incurred upon it due to the uplift load placed on the component.

4.2 Systems which are also tested for wind characteristics (henceforth 'moment based systems'), in compliance with TAS 108, shall have: 1) the restoring moment due to gravity (M_g); 2) the minimum characteristic resistance load (F′); and, 3) the attachment resistance expressed as a moment (M_f), determined under this Protocol, listed in the system manufacturer's Product Approval for reference. These values are used, in conjunction with the system's aerodynamic multiplier (l), also listed in the Product Approval, in the calculations and procedures outlined in RAS 127 to determine the acceptable method(s) of attachment for system installation on a particular building in the High-Velocity Hurricane Zone jurisdiction. While the calculations and procedures set forth in RAS 127 may be conducted by the Uniform Building Permit applicant, where the pressures (P) have been determined based on Table 1 and do not require additional signed and sealed engineering design calculations. All other calculations shall be conducted by a Professional Engineer or a Registered Architect.

4.3 Systems which are not tested for wind characteristics (henceforth uplift based systems), due to size constraints, air impermeability, or manufacturer decision, shall have: 1) the component's average weight (W); and, 2) the minimum characteristic resistance load (F′) listed in the system manufacturer's Product Approval for reference. These values are used in the calculations and procedures outlined in RAS 127 to determine the acceptable method(s) of attachment for system installation on a particular building in the High-Velocity Hurricane Zone jurisdiction. While the calculations and procedures set forth in RAS 127 may be conducted by the Uniform Building Permit applicant, where the pressures (P) have been determined based on Table 1 and do not require additional signed and sealed engineering design calculations. All other calculations shall be conducted by a Professional Engineer or a Registered Architect.

NOTE: Uplift based systems need only be tested for average weight (W) and minimum characteristic resistance load (F′) in this Protocol.

4.4 Testing in compliance with this Protocol and subsequent listing of the results in the system manufacturer's Product Approval, as noted in Sections 4.2 or 4.3, does not imply automatic approval for installation of the tested system on any building in the High-Velocity Hurricane Zone jurisdiction. The applicability of system installation shall be determined in one of the following two ways:

4.4.1 For exposure 'C' buildings having a roof mean height less than or equal to 40 feet, the Uniform Building Permit applicant may utilize the procedures set forth in RAS 127 to determine acceptable methods of attachment. The procedure outlined in Section 4.4.2 is also an option for those exposure 'C' buildings having a roof mean height less than or equal to 40 feet.

4.4.2 The Chief Code Compliance Officer shall determine the acceptability of system installation based on results from engineering design calculations in compliance with RAS 127. These calculations shall be: 1) performed for all buildings having a roof mean height greater than 40 feet; 2) performed, signed and sealed by a Professional Engineer or a Registered Architect; and, 3) shall take precedence over the procedures outlined in Section 4.4.1.

5. Apparatus

5.1 The test apparatus shall consist of a steel framework and loading bar constructed of sufficient strength to remain rigid when loads of up to 250 lbf are applied. The frame shall be fixed to a solid floor so as to prevent movement and provide a solid reference level for deflection measurements. (See Figure 1, attached.)

5.2 The loading bar position shall adjustable along the frame width to facilitate the upward loading of the 'test component.' The opposite end of the loading bar shall be attached to a hydraulic jack, or other similarly controllable mechanical device. (See Figure 1, attached.)

5.3 Component Load Transfer (See Figure 1, attached)

5.3.1 Moment-based systems shall have the static uplift load applied at a point along the center of the component, 0.76 x 1 (1 = component length) from the head of the component.

5.3.2 Uplift-based systems shall have the static uplift load applied at the center of the component.

5.3.3 Prior to test specimen construction, install one of the following load transfer devices to the 'test component' at the appropriate location, as noted in Section 5.3.1 or 5.3.2, above.

- Drill a hole at the appropriate location in the 'test component' using a 0.203 in.- 0.205 in. nonpercussion, cutting carbide bit to minimize spalling. Discard any component which, subsequent to drilling, exhibits spalling in excess of $^1/_4$ in. Install a $^1/_4$ in. diameter, threaded concrete anchor through the pre-drilled hole allowing for penetration not greater than $^1/_4$ in.

or,

- Drill a hole at the appropriate location in the 'test component' using a $^{7}/_{16}$ in. - $^{1}/_{2}$ in. nonpercussion, cutting carbide bit to minimize spalling. Discard any component which, subsequent to drilling, exhibits spalling in excess of $^{1}/_{4}$ in. Cover the bottom of the predrilled hole with duct tape and fill the hole with epoxy. Insert a $^{3}/_{8}$ in. diameter epoxy bolt into the hole and allow to cure for 24 hours prior to component installation.

5.4 A load cell, attached to or forming part of the loading bar, shall be rigidly attached to the load transfer device, noted in Section 5.4.3, to measure the load applied. The load cell shall have a digital, dial or chart recorded output capable of recording loads up to 250 lbf and a resolution of 0.5%. The load cell shall be capable of recording the ultimate load incurred upon the test component. (See Figure 1, attached.)

5.5 Linear displacement gauges (i.e. dial gauges) shall be used to record the test component, fastener and/or clip displacement. Gauges shall be firmly fixed to the plywood substrate adjacent to the 'test component.' (See Figure 1, attached.)

5.6 A measurement device with an accuracy of 0.05 lbm shall be used to determine the average mass of the 'test components.'

6. Test Limitations and Precautions

6.1 During the test, all testing agency representatives and other test observers shall wear eye protection to prevent injury.

6.2 The protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

6.3 Care must be taken not to damage, twist or distort the test specimen during handling as this may affect the test specimen's performance.

7. **Test Specimen** - 14 test specimens shall be constructed in compliance with the specification herein. **Prior to test specimen construction, refer to Section 8.1 herein.**

7.1 Deck

7.1.1 The wood test deck shall consist of APA $^{32}/_{16}$ span rated sheathing of $^{15}/_{32}$ in. thickness installed over 2 in. x 6 in. perimeter supports and 2 in. x 6 in. intermediate supports spaced 24 in. apart. The sheathing shall be attached with 8d common nails at 6 in. o.c. at panel edges and 12 in. o.c. at intermediate supports. The sheathing shall be sized to accommodate the tile installation specified in Section 7.6 while meeting the size constraints of the steel test frame. The test deck shall be capable of resisting a minimum dead load of 55 psf.

7.2 Underlayment

7.2.1 Underlayment shall be a standard 30/90 system with a 30 lb. ASTM D 226, type II anchor sheet and an ASTM D 249 mineral surface roll roofing as the top ply.

7.2.2 The anchor sheet shall be mechanically attached to the wood sheathing, with 12 ga. roofing nails and $1^{5}/_{8}$ in. tin caps, in a 12 in. grid pattern staggered in two rows in the field and 6 in. o.c. attachment at any laps. The mineral surface top ply shall be applied in a full mopping of ASTM D 312, type IV asphalt.

7.3 Fasteners

7.3.1 Component attachment fasteners (i.e. nails or screws) shall be those recommended in the system manufacturer's published installation instructions. Nails shall be not less than 0.109 in. in diameter and minimum screws shall be #8 diameter screw fasteners.

7.3.2 Clips shall be those specified by the roof system manufacturer. The type, size and manufacturer of clip shall be noted in the final test report.

7.3.3 Component attachment fasteners and clips shall meet the corrosion requirements set forth in TAS 114, Appendix E.

7.4 Battens (if applicable)

7.4.1 Horizontal Batten System

- Horizontal battens shall be of nominal 1 in. x 2 in. dimensional lumber and shall be spaced to provide a minimum 3 in. head lap, or to match the interlocking configuration of the component's profile.
- Horizontal battens shall be nailed to the wood test deck at 6 in. o.c. using 12 ga. roofing nails.

7.4.2 Counter Batten System

- Vertical battens shall be of nominal 1 in. x 4 in. lumber and shall be spaced 24 in. over the intermediate supports (trusses).
- Vertical battens shall be nailed to the wood test deck at 6 in. o.c. using 12 ga. roofing nails.
- Horizontal battens (counter battens) shall be as noted in Section 7.4.1, nailed to the 1 in. x 4 in. vertical battens using 12 ga. roofing nails of sufficient length to penetrate both battens.

7.5 Supplemental Adhesive (Optional)

7.5.1 The applicant may use a 'dab' of adhesive applied to the underside of each 'test tile' for additional component securement. The adhesive shall have a Roofing Component Product Approval for use with tile systems.

7.5.2 The tile adhesive shall be applied at the 'test tile' headlap in a single $^3/_8$ in. wide x $1^1/_4$ in. long bead placed between $1^1/_2$ in. and 2 in. from the nose of the 'test tile.'

7.6 Rigid Components

7.6.1 The type of clipped, rigid roof system shall be identified and the system's rigid components shall have an identifiable mark, confirming the system manufacturer.

7.6.2 Each component shall be installed in compliance with the system manufacturer's published installation instructions; the current Product Approval; and/or the minimum requirements set forth in Chapter 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*. The requirements of the *Florida Building Code, Building* shall take precedence.

7.6.3 The first course shall consist of two components installed at the lower edge of the test deck, either directly to the deck or over battens. The second course shall consist of the 'test component' installed over the first course, either directly to the deck or over battens, insuring for a minimum 3 in. head lap. Components in the first course, which are not tested, shall be installed to insure the test component, in the second course, is at the correct angle relative to the sheathing. (See Figure 1, attached.)

7.7 During test specimen construction, measure and record the 'test component' angle (α); the angle between the bottom surface of the 'test component' and the substrate. Record this angle for each of the 14 test specimens and determine an average 'test component angle.'

7.8 The test specimen shall be inspected by a Professional Engineer or Registered Roof Consultant who shall certify, in the final test report, that it was constructed in compliance with the provisions of this Protocol.

8. Procedure

8.1 Prior to installing the 'test components' on the test specimens, determine the mass of the 14 'test components' to an accuracy of 0.05 lbm, tabulate the data and determine the average mass.

8.2 Mount one of the 14 test specimens on the test apparatus at the predetermined test slope (θ), as noted in Section 1.2.

8.3 Position the displacement devices to measure displacement in the direction of the applied load. Position one device at the nose of the 'test component,' one device at each fastener point and one device over each clip.

8.4 Connect the loading and load measurement devices rigidly to the load transfer device, noted in Section 5.4.3, and apply an uplift load. Care shall be taken to ensure that the uplift load is applied vertically and that the 'test component's' displacement rate does not exceed 2 in. per minute.

8.5 An observer shall monitor the component, its attachment point(s), the clip(s) and the displacement gauge(s) while a second observer monitors the load measuring device. Record the ultimate load at which: 1) the 'test component,' fastener or clip breaks or cracks; 2) the nose of the 'test component' vertically displaces $^1/_4$ in.; 3) a fastener vertically displaces $^1/_4$ in.; or, 4) a clip vertically displaces $^1/_8$ in.

8.6 Repeat Sections 8.2 through 8.5 for each of the remaining test specimens and tabulate the ultimate uplift loads.

9. Calculations

9.1 Weight (W)

9.1.1 Determine the average weight of the 14 'test components' using the average mass of these components, determined in Section 8.1, and the following equation.

$$W = m \times \left[\frac{1\ slug}{32.174\ lbm} \right] \times g \qquad \text{where,}$$

W = average component weight (lbf);

m = average component mass (lbm); and,

g = 32.2 ft/s^2 = acceleration of gravity constant.

NOTE: 1 slug = 1 lbf s^2/ ft

9.2 Restoring Moment due to Gravity (M_g)

NOTE: This calculation need only be performed for moment based systems.

9.2.1 Determine the restoring moment due to gravity (M_g) at the test slope (θ) using the component's average weight (W), determined in Section 9.1, the 'test component angle' (α), determined in Section 7.7, and the following equation.

$$M_g = W \text{ x } \cos(\theta - \alpha) \text{ x } L_g \qquad \text{where,}$$

M_g = restoring moment due to gravity (ft-lbf);

W = component's average weight (lbf);

L_g = component's gravitational moment arm (ft);

θ = test slope (degrees); and,

α = 'test component angle' (degrees)

NOTES:

1. The component's gravitational moment arm (L_g) is the orthogonal distance from the component's center of gravity to its axis of rotation.

2. For 'S' shaped clay or concrete tile, the axis of rotation is located toward the upper left corner of the tile. For such tile attached directly to the deck, a gravitational moment arm of L_g = 0.728 feet has been found to be typical. For such tile attached through battens, a gravitational moment arm of L_g = 0.679 feet has been found to be typical. The testing agency shall confirm these values through measurement prior to use in the above noted equation.

3. For all other components attached directly to the deck:

L_g = (0.5 x l) where,

l = component length.

4. For all other components attached through battens:

L_g = (0.5 x l) - y where,

l = component length; and,

y = distance from head of component to center line of horizontal batten

9.3 Statistical Analysis of Test Data

9.3.1 From the 14 recorded ultimate loads, eliminate the 'high' and 'low' values leaving 12 ultimate load values for statistical analysis.

9.3.2 Determine the mean ultimate load (F) and the standard deviation (S_F) using the tabulated data from Section 8 and the following equations.

$$\overline{F}=\frac{1}{12}\sum_{i=1}^{12}F_i$$

$$S_F=\sqrt{\frac{1}{11}\sum_{i=1}^{12}\left(F_i-\overline{F}\right)^2} \qquad \text{where,}$$

$\overline{F}$ = average ultimate load (lbf);

S_F = standard deviation;

F = recorded ultimate load; and,

i = 1, 2, 3, . . . , 12 = test number.

9.3.3 Determine the percent deviation from the mean (S'_F) using information from Section 9.3.2 and the following equation.

$$S'_F=\left(\frac{S_F}{F}\right)\times 100 \qquad \text{where,}$$

S'_F = percent deviation from the mean (%);

S_F = standard deviation; and,

F = mean ultimate load.

9.3.3.1 If the percent deviation from the mean (S'_F) is greater than or equal to 20%, the test results shall be considered null and void and the test shall be considered a retest.

9.4 Minimum Characteristic Resistance Load (F′)

9.4.1 Determine the minimum characteristic resistance load (F′) using the mean ultimate load and the following equation.

$$F'=\left(\frac{\overline{F}-W}{MS}\right) \qquad \text{where,}$$

F′ = minimum characteristic resistance load;

F = mean ultimate load;

MS = margin of safety = 2; and,

W = average weight.

NOTE: The requirement noted in Section 9.3.3.1 shall be met prior to determining the minimum characteristic resistance load (F′).

9.5 Attachment Resistance Expressed as a Moment (M_f)

NOTE: This calculation need only be performed for moment based systems.

9.5.1 Determine the attachment resistance expressed as a moment (M_f) provided by the component's attachments at test slope (θ) using the minimum characteristic resistance load (F′), determined in Section 9.4.1, the 'test tile angle' (α), determined in Section 7.7, and the following equation.

M_f = [F′ x cos ($\theta-\alpha$) x L_f] where,

M_f = attachment resistance (ft-lbf);

F′ = minimum characteristic resistance load (lbf);

L_f = tile's attachment moment arm (ft);

θ = test slope (degrees); and,

α = test tile angle (degrees).

NOTES:

1. The component's attachment moment arm (Lf) is the orthogonal distance from the point of load application to its axis of rotation.

2. Components Other Than 'S' Shaped Clay or Concrete Tile:

   Direct deck:

   L_f = (0.76 x l) where,

   l = component length.

   Over battens:

   L_f = (0.76 x l) - y where,

   l = component length; and,

   y = distance from head of component to centerline of horizontal batten

3. 'S' Shaped Clay or Concrete Tile: For 'S' shaped clay or concrete tile, the axis of rotation is located toward the upper left corner of the tile. For this reason the tile's attachment moment arm (L_f) shall be measured for the tile in question, either installed directly to the deck or over battens. Measure the orthogonal distance from the point of load application (as noted in Section 5.3.1) to the axis of rotation. This distance is the tile's attachment moment arm (L_f).

10. Report

10.1 The final test report shall include the following:

10.1.1 A description and sketch of the rigid component designed for use in the clipped, rigid roof system, including the manufacturer and type of component.

10.1.2 A description and sketch of the clip designed for use in the system, including the manufacturer and type of clip.

10.1.3 A statement of which load transfer device, noted in Section 5.4, was utilized and which test slope (θ) was selected by the manufacturer.

10.1.4 A detailed report of the method of test specimen construction, including a photograph of the test specimen and certification by a Professional Engineer or Registered Roof Consultant that the test specimen was constructed in compliance with the specifications of the Protocol.

10.1.5 Tabulated results of mass measurements of the 14 'test components' and an average mass.

10.1.6 Tabulated 'test component angle' (α) measurements for the 14 test specimens and an average 'test component angle,'

10.1.7 Tabulated ultimate clip load measurements (F1, F2, F3, . . . F12) for the 14 test specimens.

10.1.8 Average component weight (W) calculations and results.

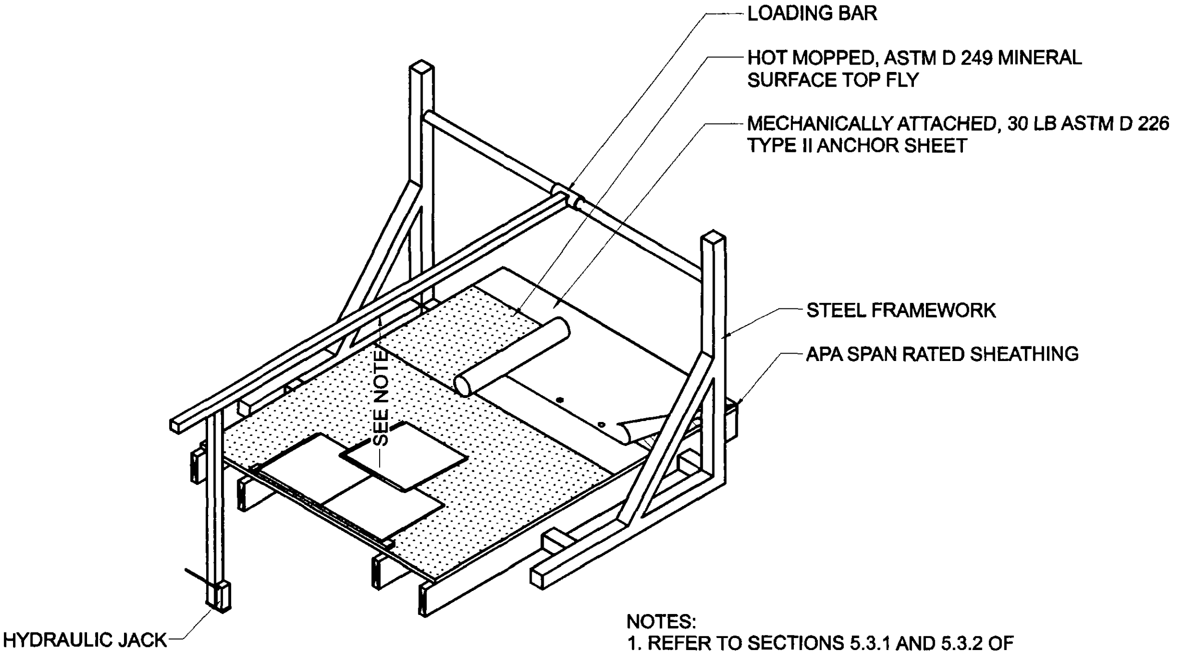
10.1.9 Restoring moment due to gravity (M_g) calculations and results (needed only for moment based systems).

10.1.10 Calculations and results confirming the percent deviation from the mean (S'_F) less than 20%.

10.1.11 Minimum characteristic resistance load (F') calculations and results.

10.1.12 Attachment resistance expressed as a moment (M_g) calculations and results (needed only for moment based systems).

10.1.13 A video tape of all pertinent aspects of the test, including test specimen construction and uplift load applications.


LOADING BAR
HOT MOPPED, ASTM D 249 MINERAL SURFACE TOP FLY
MECHANICALLY ATTACHED, 30 LB ASTM D 226 TYPE II ANCHOR SHEET
STEEL FRAMEWORK
APA SPAN RATED SHEATHING
SEE NOTE
HYDRAULIC JACK

NOTES:

1. REFER TO SECTIONS 5.3.1 AND 5.3.2 OF THIS PROTOCOL FOR THE POINT OF LOAD APPLICATION

FOR MOMENT BASED SYSTEM: POINT = 0.76 x LENGTH

FOR MOMENT UPLIFT SYSTEM: POINT = CENTER OF COMPONENT

FIGURE 1
STATIC UPLIFT TEST APPARATUS

ROOFING APPLICATION STANDARD (TAS) No. 103-95

TEST PROCEDURE FOR SELF-ADHERED UNDERLAYMENTS FOR USE IN DISCONTINUOUS ROOF SYSTEMS

1. Scope

1.1 This Protocol covers procedures for testing self-adhering, prefabricated, reinforced, polymer modified bituminous, and solid thermoplastic sheet roofing materials intended for use as underlayment in Discontinuous Roof Systems to assist in the waterproofing to function in combination with a Prepared Roof Covering. These products may employ granular surfacing materials on one side in which case the "Granular Adhesion" test, as specified herein, shall also be conducted. The Granular Adhesion test shall be required for all granular surfaced materials used as a bonding surface for mortar or adhesive set tile systems.

1.2 The test procedures outlined in this Protocol cover the determination of the Wind Uplift Resistance; the Thickness; the Dimensional Stability; the Tear Resistance; the Breaking Strength; the Elongation; the Water Absorption; the Low Temperature Flexibility; the Ultraviolet Resistance; the Accelerated Aging Performance; the Cyclic Elongation Performance; the Water Vapor Transmission; the Compound Stability; the Puncture Resistance; the Tile Slippage Resistance; the Crack Cycling Resistance; and the Peel Resistance of an underlayment material; and Granular Adhesion of a mineral surfaced roll roofing material, for use as an underlayment.

1.3 These test methods appear in the following order:

	Section
Conditioning	5
Thickness	6
Wind Uplift	7
Dimensional Stability	8
Tear Resistance	9
Breaking Strength and Elongation	10
Water Absorption	11
Low Temperature Flexibility	12
Ultraviolet Resistance	13
Accelerated Aging	14
Cyclic Elongation	15
Water Vapor Transmission	16
Compound Stability	17
Puncture Resistance	18
Tile Slippage Resistance	19
Crack Cycling	20
Peel Resistance	21
Granule Adhesion	22

2. Referenced Documents

2.1 *ASTM Test Standards:*

D1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
D 1938	Tear Propagation Resistance of Plastic Film and Thin Sheeting by a Single-Tear Method
D 2523	Testing Load-Strain Properties of Roofing Membranes
D 570	Water Absorption of Plastics
D 1970	Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection (Low Temperature Flexibility)
E 96	Water Vapor Transmission of Materials
D 5147	Sampling and Testing Modified Bituminous Sheet Materials
C 794	Adhesion-in-Peel of Elastomeric Joint Sealants
E 380	Excerpts from the Standard Practice for Use of the Interna-

tional System of Units (SI) (the Modernized Metric System)

2.2 *International Conference of Building Officials*
Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas Acceptance Criteria For Concrete Tile Underlayment On Spaced Sheathing

2.3 *American Plywood Association*
Performance Standards and Policies for Structural-Use Panels

2.4 *The Florida Building Code, Building.*

2.5 *Application Standards*

TAS 124 Test Procedure for Field Uplift Testing of Existing Membrane Roof Systems

2.6 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units

3.1 Definitions - For definitions of terms used in this Protocol, refer to ASTM D 1079; Chapters 2 and 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use

4.1 The test procedures outlined in this Protocol provide a means of determining whether a self-adhering roofing material, intended for use as an underlayment in a Discontinuous Roof System, for use in the High-Velocity Hurricane Zones, meets the requirements of the *Florida Building Code, Building.*

5. Conditioning

5.1 Unless otherwise specified, condition test specimens for a minimum of four (4) hours at 73.4 ± 3.6°F and 50 ± 5% relative humidity prior to testing. Note separate conditioning requirements for cold bend testing in Section 12.1.

6. Thickness

6.1 Materials shall be checked at five points across the roll width. Measurements shall be made at two points, each being 6 ± 0.5 inches from each edge, and at three points equally spaced between these two points.

6.2 Compute the average thickness and the standard deviation of the thicknesses, in mils, based on the total number of point measurements from all of the rolls taken.

6.3 Report the individual point measurements, average, and standard deviation in mils.

6.4 Any modified bitumen and bituminous membrane test specimen which exhibits an average thickness less than sixty (60) mils shall be considered as failing the thickness test. Thickness measurements shall be at the selvage edge, not at a granular surface.

6.5 Nonbituminous membranes shall not have a thickness minimum. Performance shall be based on physical property testing.

7. Wind Uplift

7.1 This test covers the determination of the wind uplift resistance of materials specified in Section 1 of this Protocol in accordance with TAS 124 except as noted below.

7.1.1 Sampling

7.1.1.1 Test is being conducted on materials noted in Section 1 of this Protocol; therefore, any reference to "roof membrane" in TAS 124 shall be regarded as 'underlayment.'

7.1.1.2 Four (4) 8 in. x 8' test decks shall be constructed of 40/20 $^{19}/_{32}$ in. APA Rated Sheathing attached to wood joists spaced 24 o.c. Each test deck shall consist of four (4) panels of said sheathing, the corners of which shall meet at the center of each test deck, leaving a $^{1}/_{8}$ in. gap between panels.

7.1.1.3 Adhere one (1) layer of underlayment to each test deck.

7.1.2 Procedure

7.1.2.1 Test shall be a laboratory test not a field test; therefore, any instruction in TAS 124 which references "building or outdoor conditions" shall be shall be regarded as 'laboratory conditions.'

7.1.2.2 Regulate the negative pressure in the chamber. Begin by raising the negative pressure in the chamber to 30 lbf/ft^2 and holding this pressure for one (1) minute. Thereafter, raise the negative pressure in increments of 15 lbf/ft^2, holding each incremented pressure for one (1) minute, until the negative pressure has been held at 90 lbf/ft^2 for one (1) minute.

7.1.3 Report

7.1.3.1 Any test specimen which exhibits any deflection or significant blistering from the sheathing surface shall be considered as failing the wind uplift test.

8. Dimensional Stability

8.1 Prepare five (5) 2 foot wide x 6 foot long specimens with a 4 inch overlap seam across the center of the 6 foot length. Prepare the specimens: one from each edge of the roll and three from random places in the roll. The length of each specimen should be in the 'machine direction' of the roll.

8.2 The substrate shall be APA 32/16 span rated sheathing of a $^{15}/_{32}$ in. thickness that has been reinforced on the back side with two angle irons.

8.3 Adhere the underlayment specimen on the substrate and install a $1^{1}/_{2}$ in. x $1^{1}/_{2}$ in. x 2' wood termination batten to one 'free' end of the underlayment using three (3) equally spaced #12 wood screws to secure the batten through the underlayment and the sheathing. Mechanically attach the other 'free' end of the underlayment using three (3) equally spaced 10d roofing nails, located two (2) inches from the 'free' end, with one nail at one inch from each edge, penetrating the sheathing a minimum of $^{1}/_{2}$ inch.

8.4 Condition each specimen in an oven or under heat lamps maintained at 180 ± 5°F for a minimum of six (6) hours.

8.5 Report any tears or 'tear drop' conditions which arise at fastener penetrations during and/or after conditioning is complete. Report any shrinking or wrinkling which appears to have compromised the lapped area of underlayment.

8.6 Any test specimen which exhibits conditions noted in Section 8.5 of this Protocol shall be considered as failing the dimensional stability test.

8.7 Provide before and after photographs of each specimen in the final test report.

9. Tear Resistance

9.1 This test covers the determination of the tear propagation resistance of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method D 1938, except as noted below.

9.1.1 The prescribed Test Method shall be run in both the machine and the cross-machine direction of the roll material.

9.1.2 The final test report shall include average tear propagation force values and standard deviations of these value for both the machine and the cross-machine direction of the material.

9.1.3 Any test specimen which exhibits a tear propagation value less than 3.5 lbf (15.5 N) in either the machine or cross-machine directions shall be considered as failing the tear strength test.

10. Breaking Strength and Elongation

10.1 This test covers the determination of the breaking strength and elongation of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method D 2523, except as noted below.

10.1.1 Sampling

10.1.1.1 Ten specimens; five in the machine direction and five in the cross-machine direction of the roll, shall be cut to dimensions of 1 in. x 6 in.

10.1.2 Conditioning

10.1.2.1 Heat Aging, shall consist of seven (7) days in an air circulating oven at a controlled temperature of 149 ± 5°F.

10.1.2.2 QUV Exposure, shall consist of 460 hours of continuous ultraviolet light exposure.

10.1.3 Procedure

10.1.3.1 Each set of samples, as specified in 10.1.1.1 herein, shall be tested 'as received', after heat aging, and after QUV exposure, as specified in 10.1.2.1 and 10.1.2.2 herein.

10.1.3.2 Grip separation rate shall be 20 ± 0.2 inches per minute for all tests conducted.

10.1.3.3 Testing shall be performed at 77°F for all tests.

10.1.3.4 Specimens and testing grips shall be conditioned at 77°F for a minimum of one (1) hour prior to testing.

10.1.4 Report

10.1.4.1 Report the grip separation rate used.

10.1.4.2 Breaking strength shall be reported, in lbf/inch of width, for all test specimens and shall be itemized in grouping of 'as received,' after heat conditioning, and after QUV exposure. These grouping shall be itemized in subgroups of machine direction and cross-machine direction. Any test specimen which exhibits a breaking strength value less than those listed in Table 1 shall be considered as failing the breaking strength test.

TABLE 1
MINIMUM BREAKING STRENGTH VALUES

SPECIMEN	BREAKING STRENGTH
	(Machine Direction or Cross-Machine Direction)
As Received	20 lbf/inch of width (35 N/cm of width)
After Heat Aging	85% of 'as received'
After QUV Exposure	85% of 'as received'

10.1.4.3 Elongation shall be reported, in (%), for all test specimens and shall be itemized in grouping of 'as received,' after heat conditioning, and after QUV exposure. These grouping shall be itemized in subgroups of machine direction and cross-machine direction. Any test specimen which exhibits elongation values less than those listed in Table 2 shall be considered as failing the elongation test.

TABLE 2
MINIMUM ELONGATION VALUES (%)

SPECIMEN	ORGANIC REINFORCEMENT	FIBERGLASS REINFORCED	POLYESTER OR POLYPROPYLENE REINFORCED	SOLID THERMOPLASTIC SHEATHING
As Received	MD 6% XMD 6%	MD 3% XMD 3%	MD 25% XMD 25%	MD 225% XMD 225%
Aster Heat Aging	85% of 'as received'	85% of 'as received'	85% of 'as received'	85% of 'as received'
After QUV Exposure	85% of 'as received'	85% of 'as received'	85% of 'as received'	85% of 'as received'

11. Water Absorption

11.1 This test covers the determination of the water absorption of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method D 570, except as noted below.

11.1.1 Preparation

11.1.1.1 Edges of membranes which include internal reinforcement as a component shall be sealed with wax to prevent water absorption through these edges. Wax shall cover not more than 0.25 in. at each edge.

11.1.1 Conditioning

11.1.1.1 Conditioning shall consist of 72 continuous hours of exposure to temperatures and relative humidity specified in Section 5 of this Protocol.

11.1.2 Report

11.1.2.1 Any test specimen which exhibits water absorption values greater than 3% shall be considered as failing the water absorption test.

12. Low Temperature Flexibility

12.1 This test covers the determination of the low temperature flexibility of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method D 1970 (7.4), except as noted below. Membranes shall be tested at -10°F.

12.1.1 Procedure

12.1.1.1 Each set of specimens shall be tested 'as received' and after conditioning, as specified in ASTM D 1970 (7.4.2).

12.1.2 Report

12.1.2.1 Low temperature flexibility results shall be reported on a pass/fail basis, for all test specimens and shall be itemized in grouping of 'as received' and after conditioning. No cracking at -10°F shall be considered as passing the low temperature flexibility test.

13. Ultraviolet Resistance

13.1 This test covers the determination of the ultraviolet resistance performance of materials specified in Section 1 of this Protocol in accordance with the ICBO Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas (Section IV-H), except as noted below.

13.1.1 Sampling - Two 18 in. x 18 in. specimens are to be cut.

13.1.2 Conditioning

13.1.2.1 Conditioning shall be in accordance with ICBO Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas (Section IV-H), except as noted below.

13.1.2.2 Ultraviolet light shall be produced by four 300 watt UV lamps. Recommended lamps are Ultra-Vitalux, 300 W, 220-230 V, #E27, or oshram 300 W lamps.

13.1.2.3 Specimens to be exposed for 200 hours (10 hours per day for 20 days).

13.1.2.4 Specimen temperature to be maintained at 135-140°F throughout the test period.

13.1.3 Report & Conditions of Acceptance

13.1.3.1 Report any visible peeling, chipping, cracking, flaking, pitting or other damage, under 5x magnification, which resulted from the ultraviolet conditioning. Report the type and location of the damage (if any).

13.1.3.2 Report the type of UV lamps used to condition the samples.

13.1.3.3 Any test specimen which exhibits damage as defined in Section 13.1.2.1 of this Protocol shall be considered as failing the ultraviolet resistance test.

13.1.3.4 Do no subject the ultraviolet exposed specimens to "tensile strength and peel-adhesion test" as noted in the ICBO Acceptance Criteria Document. The 'breaking strength' shall be addressed as specified in Section 9 of this Protocol and 'peel-adhesion' will not be a requirement of this Protocol.

14. Accelerated Aging

14.1 This test covers the determination of the accelerated aging performance of materials specified in Section 1 of this Protocol in accordance with the ICBO Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas (Section IV-G), except as noted below.

14.1.1 Sampling

14.1.1.1 The six (6) 12 in. x 12 in. specimens shall be prepared with three (3) in the machine direction and three (3) in the cross-machine direction of the roll.

14.1.2 Conditions of Acceptance

14.1.2.1 Do not subject the aged specimens to "tests in accordance with Section III A, D and E". Water ponding tests ("Section III D") and peel-adhesion tests ("Section III E") are not requirements of this Protocol. The noted "Section III A" shall be addressed in Section 13.1.3 of this Protocol.

14.1.3 Breaking strength and elongation tests of aged specimens shall be conducted in accordance with Section 10 of this Protocol, except as noted below.

14.1.3.1 Sampling - After the six (6) 12 in. x 12 in. aged specimens have been examined for visible damage, prepare ten (10) 1 in. x 6 in. specimens from the aged material; five in the machine direction and five in the cross-machine direction of the roll. In addition to these ten aged specimens, prepare ten 'as received' specimens of the same dimensions; five in the machine direction and five in the cross-machine direction of the roll.

14.1.3.2 Conditioning - No further conditioning is to be incurred on the aged specimens.

14.1.3.3 Procedure - Each set of samples, as specified in 13.1.3.1 herein, shall be tested 'as received' and after accelerated aging.

14.1.3.4 Report

14.1.3.4.1 Breaking strength shall be reported, in lbf/inch of width, for all test specimens and shall be itemized in grouping of 'as received' and after accelerated aging. These grouping shall be itemized in subgroups of machine direction and cross-machine direction. Any aged specimen which exhibits a breaking strength less than 85% of the 'as received' value shall be considered as failing the accelerated aging test.

14.1.3.4.2 Elongation shall be reported, in (%), for all test specimens and shall be itemized in grouping of 'as received' and after accelerated aging. These grouping shall be itemized in subgroups of machine direction and cross-machine direction. Any aged specimen which exhibits an elongation value greater than 85% of the 'as received' value shall be considered as failing the accelerated aging test.

15. Cyclic Elongation

15.1 This test covers the determination of the cyclic elongation performance of materials specified in Section 1 of this Protocol in accordance with the ICBO Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas (Section IV F), except as noted below.

15.1.1 Specimens shall be adhered over the two pieces of sheathing.

15.1.2 The three specimens shall be prepared with 32/16 $^{15}/_{32}$ in. x 3 in. x 6 in. APA span rated sheathing.

15.1.3 Any test specimen which exhibits cracking of material shall be considered as failing the cyclic elongation test.

16. Water Vapor Transmission

16.1 This test covers the determination of the water vapor transmission of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method E96, procedure B.

16.2 The water vapor transmission of the membrane shall not be greater than 1.0 g/m^2 in 24 hours.

17. Compound Stability

17.1 This test covers the determination of the high temperature stability of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method D 5147, Section 15, except as noted below.

17.1.1 Any test specimen which exhibits flowing, dripping or drop formation at a temperature less than 220°F shall be considered as failing the compound stability test.

18. Puncture Resistance

18.1 This test covers the determination of the puncture resistance of materials specified in Section 1 of this Protocol in accordance with the ICBO Acceptance Criteria For Concrete Tile Underlayment On Spaced

Sheathing (Section 5.0, d,2), except as noted below.

18.1.1 Two 12 in. x 25 in. specimens shall be prepared; one ultraviolet light conditioned and one accelerated aging conditioned, as specified in Sections 13 and 14 of this Protocol, respectively.

18.1.2 Any test specimen which exhibits any sign of puncture shall be considered as failing the puncture test.

19. Slippage Resistance

19.1 Prepare three (3) 4 foot wide x 8 foot long specimens with a 4 inch overlap seam across the center of the 8 foot length. Prepare the specimens: one from one edge of the roll and one from the center of the roll. The length of each specimen should be in the 'machine direction' of the roll.

19.2 The substrate shall be 32/16 $^{15}/_{32}$ in. APA span rated sheathing that has been reinforced on the back side with two angle irons.

19.3 Adhere the underlayment to the substrate.

19.4 Condition each test deck in an oven or under heat lamps maintained at 135 ± 5°F for a minimum of four (4) hours. Thereafter, the deck shall be cooled for three hours at 75° ± 5°F.

19.5 After conditioning, position one test deck at a slope of 4 in:12 in.; one at a slope of 5 in:12 in.; and the third at a slope of 6 in:12 in. The 5 in:12 in. test deck may be omitted if requested by the client.

19.6 Onto each sloped test deck, place one (1) stack of 10 flat concrete tiles and one (1) stack of 10 profiled tiles manufactured with 'lugs' on the underside of each tile. Allow the tile stacks to sit on the underlayment surface for 72 hours while maintaining a controlled surface temperature of 165° ± 5°F. Temperature to be maintained by a surface mounted thermocouple.

19.7 Report any tears or tile slippage on any portion of the underlayment.

19.8 Any test specimen which exhibits conditions noted in Section 19.7 of this Protocol shall be considered as failing the tile slippage resistance test.

19.9 Provide before and after photographs of each specimen in the final test report.

20. Crack Cycling

20.1 This test covers the determination of the crack cycling performance of materials specified in Section 1 of this Protocol in accordance with the ICBO Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas (Section IV, F), except as noted below.

20.1.1 Specimens shall be adhered over the two pieces of sheathing.

20.1.2 The three specimens shall be prepared with 32/16 $^{15}/_{32}$ in. x 3 in. x 6 in. APA span rated sheathing.

20.1.3 Conditioning shall consist of exposure to a controlled temperature of 180 ± 5°F and 55 ± 5% relative humidity for a period of seven (7) days.

20.1.4 Any test specimen which exhibits cracking of material shall be considered as failing the cyclic elongation test.

21. Peel Adhesion

21.1 This test covers the determination of the peel adhesion to substrate performance of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method D 1970 (7.4), except as noted below.

21.1.1 Specimen Preparation

21.1.1.1 The substrate shall be APA 32/16 span rated sheathing of a $^{15}/_{32}$ in. thickness.

21.1.2 Conditioning

21.1.2.1 One set of samples shall be conditioned at 75 ± 2°F for four (4) hours; a second and third set shall be conditioned as specified in the ICBO Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas, Sections IV-G and IV-H for accelerated aging and ultraviolet resistance, respectively.

21.1.1 Report

21.1.3.1 Peel Adhesion shall be reported, in lbf/foot of width, for all test specimens and shall be itemized in grouping of 'conditioned at 75°F,' 'after accelerated aging' and 'after ultraviolet conditioning.'

21.1.3.2 Any 'conditioned' specimen which exhibits a peel strength less than 6.5 lbf/foot of width shall be considered as failing the peel adhesion test.

21.1.3.3 Any aged or ultraviolet conditioned specimen which exhibits a peel strength less than 75% of the 'conditioned at 75°F' value shall be considered as failing the peel adhesion test.

FOR MINERAL SURFACED ROLL MATERIAL TO BE USED AS A MORTAR SET TILE UNDERLAYMENT

22. Granule Adhesion

22.1 This test covers the determination of granule loss of materials specified in Section 1 of this Protocol, which employ a granular surfacing on one side, in accordance with ASTM Test Method D 5147, Section 14, except as noted below.

22.1.1 Any test specimen which exhibits an average granule loss greater than 0.75 grams shall be considered as failing the granule adhesion test.

TESTING APPLICATION STANDARD (TAS) No. 104-95

TEST PROCEDURE FOR NAIL-ON UNDERLAYMENT FOR USE IN DISCONTINUOUS ROOF SYSTEMS

1. Scope

1.1 This Protocol covers procedures for testing mechanically attached, prefabricated, reinforced, polymer modified bituminous, and solid thermoplastic sheet roofing materials intended for use as underlayment in Discontinuous Roof Systems to assist in the waterproofing to function in combination with a Prepared Roof Covering. These products may employ granular surfacing materials on one side in which case the "Granular Adhesion" test, as specified herein, shall also be conducted. The Granular Adhesion test shall be required for all granular surfaced materials used as a bonding surface for mortar or adhesive set tile.

1.2 The test procedures outlined in this Protocol cover the determination of the Thickness; the Dimensional Stability; the Tear Resistance; the Breaking Strength; the Elongation; the Water Absorption; the Low Temperature Flexibility; the Ultraviolet Resistance; the Accelerated Aging Performance; the Cyclic Elongation Performance; the Water Vapor Transmission; the Puncture Resistance; and the Tile Slippage Resistance of an underlayment material; and Granular Adhesion of a mineral surfaced roll roofing material, for use as an underlayment.

1.3 These test methods appear in the following order:

	Section
Conditioning	5
Thickness	6
Dimensional Stability	7
Tear Resistance	8
Breaking Strength and Elongation	9
Water Absorption	10
Low Temperature Flexibility	11
Ultraviolet Resistance	12
Accelerated Aging	13
Cyclic Elongation	14
Water Vapor Transmission	15
Puncture Resistance	16
Tile Slippage Resistance	17
Granule Adhesion	18

2. Referenced Documents

2.1 *ASTM Test Standards*

D 1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
D 1938	Tear Propagation Resistance of Plastic Film and Thin Sheeting by a Single-Tear Method
D 2523	Testing Load-Strain Properties of Roofing Membranes
D 570	Water Absorption of Plastics
D 1970	Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection (Low Temperature Flexibility)
E 96	Water Vapor Transmission of Materials
D 5147	Sampling and Testing Modified Bituminous Sheet Materials
E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.2 *International Conference of Building Officials*

Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas

Acceptance Criteria For Concrete Tile Underlayment On Spaced Sheathing

2.3 *American Plywood Association* Performance Standards and Policies for Structural-Use Panels

2.4 *The Florida Building Code, Building.*

2.5 *Roof Consultants Institute* Glossary of Terms

3. Terminology & Units

3.1 Definitions - For definitions of terms used in this Protocol, refer to ASTM D 1079; Chapters 2 and 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*; and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use

4.1 The test procedures outlined in this Protocol provide a means of determining whether a mechanically attached roofing material, intended for use as an underlayment in a Discontinuous Roof System, for use in the High-Velocity Hurricane Zones, meets the requirements of the *Florida Building Code, Building.*

5. Conditioning

5.1 Unless otherwise specified, condition test specimens for a minimum of four hours at 73.4 ± 3.6°F and 50 ± 5 % relative humidity prior to testing. Note separate conditioning requirements for cold bend testing in Section 11.1.

6. Thickness

6.1 Materials shall be checked at five points across the roll width. Measurements shall be made at two points, each being 6 ± 0.5 inches from each edge, and at three points equally spaced between these two points.

6.2 Compute the average thickness and the standard deviation of the thicknesses, in mils, based on the total number of point measurements from all of the rolls taken.

6.3 Report the individual point measurements, average, and standard deviation in mils.

6.4 Any modified bitumen and bituminous test specimen which exhibits an average thickness less than sixty (60) mils shall be considered as failing the thickness test. Thickness measurements shall be at the selvage edge, not at a granular surface.

6.5 Nonbituminous membranes shall not nave a thickness minimum. Performance shall be based on physical property testing.

7. Dimensional Stability

7.1 Prepare five (5) 2 foot wide x 6 foot long specimens with a 4 inch overlap seam across the center of the 6 foot length. Prepare the specimens: one from each edge of the roll and three from random places in the roll. The length of each specimen should be in the 'machine direction' of the roll.

7.2 The substrate shall be $^{32}/_{16}$ APA span rated sheathing of a $^{15}/_{32}$ in. thickness that has been reinforced on the back side with two angle irons.

7.3 Place the underlayment specimen on the substrate and install a $1^{1}/_{2}$ in. x $1^{1}/_{2}$ in. x 2' wood termination batten to one 'free' end of the underlayment using three (3) equally spaced #12 wood screws to secure the batten through the underlayment and the sheathing. Mechanically attach the other 'free' end of the underlayment using three (3) equally spaced 10d roofing nails, located two (2) inches from the 'free' end, with one nail at one inch from each edge, penetrating the sheathing a minimum of $^{1}/_{2}$ inch.

7.4 Condition each specimen in an oven or under heat lamps maintained at 180 ± 5°F for a minimum of six (6) hours.

7.5 Report any tears or 'tear drop' conditions which arise at fastener penetrations during and/or after conditioning is complete. Report any shrinking or wrinkling which appears to have compromised the lapped area of underlayment.

7.6 Any test specimen which exhibits conditions noted in Section 7.5 of this Protocol shall be considered as failing the dimensional stability test.

7.7 Provide before and after photographs of each specimen in the final test report.

8. Tear Resistance

8.1 This test covers the determination of the tear propagation resistance of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method D 1938, except as noted below.

8.1.1 The prescribed Test Method shall be run in both the machine and the cross-machine direction of the roll material.

8.1.2 The final test report shall include average tear propagation force values and standard deviations of these value for both the machine and the cross-machine direction of the material.

8.1.3 Any test specimen which exhibits a tear propagation value less than 3.5 lbf (15.5 N) in either the machine direction or cross-machine directions shall be considered as failing the tear strength test.

9. Breaking Strength and Elongation

9.1 This test covers the determination of the breaking strength and elongation of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method D 2523, except as noted below.

9.1.1 Sampling

9.1.1.1 Ten specimens; five in the machine direction and five in the cross-machine direction of the roll, shall be cut to dimensions of 1 in. x 6 in.

9.1.2 Conditioning

9.1.2.1 Heat Aging, shall consist of seven (7) days in an air circulating oven at a controlled temperature of 149 ± 5°F.

9.1.2.2 QUV Exposure, shall consist of 460 hours of continuous ultraviolet light exposure.

9.1.3 Procedure

9.1.3.1 Each set of samples, as specified in 9.1.1.1 herein, shall be tested 'as received,' after heat aging, and after QUV exposure, as specified in 9.1.2.1 and 9.1.2.2 herein.

9.1.3.2 Grip separation rate shall be 20 ± 0.2 inches per minute for all tests conducted.

9.1.3.3 Testing shall be performed at 77°F for all tests.

9.1.3.4 Specimens and testing grips shall be conditioned at 77°F for a minimum of one (1) hour prior to testing.

9.1.4 Report

9.1.4.1 Report the grip separation rate used.

9.1.4.2 Breaking strength shall be reported, in lbf/inch of width, for all test specimens and shall be itemized in grouping of 'as received,' after heat conditioning, and after QUV exposure. These grouping shall be itemized in subgroups of machine direction and cross-machine direction. Any test specimen which exhibits a breaking strength value less than those listed in

Table 1 shall be considered as failing the breaking strength test.

TABLE 1
MINIMUM BREAKING STRENGTH VALUES (%)

SPECIMEN	BREAKING STRENGTH (Machine Direction or Cross-Machine Direction)
As Received	20 lbf/inch of width (35 N/cm of width)
After Heat Aging	85% of "as received"
After QUV Exposure	85% of "as received"

9.1.4.3 Elongation shall be reported, in (%), for all test specimens and shall be itemized in grouping of 'as received,' after heat conditioning, and after QUV exposure. These grouping shall be itemized in subgroups of machine direction and cross-machine direction. Any test specimen which exhibits elongation values less than those listed in Table 2 shall be considered as failing the elongation test.

10. Water Absorption

10.1 This test covers the determination of the water absorption of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method D 570, except as noted below.

10.1.1 Specimen Preparation

10.1.1.1 Edges of membranes which include internal reinforcement as a component shall be sealed with wax to prevent water absorption through these edges. Wax shall cover not more than 0.25 in. at each edge.

10.1.2 Conditioning

10.1.2.1 Conditioning shall consist of 72 continuous hours of exposure to temperatures and relative humidity specified in Section 5 of this Protocol.

10.1.3 Report

10.1.3.1 Any test specimen which exhibits water absorption values greater than 3% shall be considered as failing the water absorption test.

11. Low Temperature Flexibility

11.1 This test covers the determination of the low temperature flexibility of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method D 1970 (7.7), except as noted below. Membranes shall be test at 5°F.

11.1.1 Procedure

11.1.1.1 Each set of specimens shall be tested 'as received' and after conditioning, as specified in ASTM D 1970 (7.7.2).

11.1.2 Report

11.1.2.1 Low temperature flexibility results shall be reported on a pass/fail basis, for all test specimens and shall be itemized in grouping of 'as received' and after conditioning.

TABLE 2
MINIMUM ELONGATION VALUES (%)

SPECIMEN	ORGANIC REINFORCEMENT	FIBERGLASS REINFORCED	POLYESTER OR POLYPROPYLENE REINFORCED	SOLID THERMOPLASTIC SHEATHING
As Received	MD 6% XMD 6%	MD 3% XMD 3%	MD 25% XMD 25%	MD 225% XMD 225%
Aster Heat Aging	85% of "as received"	85% of "as received"	85% of "as received"	85% of "as received"
After QUV Exposure	85% of "as received"	85% of "as received"	85% of "as received"	85% of "as received"

12. Ultraviolet Resistance

12.1 This test covers the determination of the ultraviolet resistance performance of materials specified in Section 1 of this Protocol in accordance with the ICBO Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas (Section IV-H), except as noted below.

12.1.1 Sampling - Two 18 in. x 18 in. specimens are to be cut.

12.1.2 Conditioning

12.1.2.1 Conditioning shall be in accordance with ICBO Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas (Section IV-H), except as noted below.

12.1.2.2 Ultraviolet light shall be produced by four 300 watt UV lamps. Recommended lamps are Ultra-Vitalux, 300 W, 220-230 V, #E27, or oshram 300 W lamps.

12.1.2.3 Specimens to be exposed for 200 hours (10 hours per day for 20 days).

12.1.2.4 Specimen temperature to be maintained at 135-140°F throughout the test period.

12.1.3 Report & Conditions of Acceptance

12.1.3.1 Report any visible peeling, chipping, cracking, flaking, pitting or other damage, under 5x magnification, which resulted from the ultraviolet conditioning. Report the type and location of the damage (if any).

12.1.3.2 Report the type of UV lamps used to condition the samples.

12.1.3.3 Any test specimen which exhibits damage as defined in Section 12.1.2.1 of this Protocol shall be considered as failing the ultraviolet resistance test.

12.1.3.4 Do not subject the ultraviolet exposed specimens to “tensile strength and peel-adhesion test” as noted in the ICBO Acceptance Criteria Document. The ‘breaking strength’ shall be addressed as specified in Section 9 of this Protocol and ‘peel-adhesion’ will not be a requirement of this Protocol.

13. Accelerated Aging

13.1 This test covers the determination of the accelerated aging performance of materials specified in Section 1 of this Protocol in accordance with the ICBO Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas (Section IV-G), except as noted below.

13.1.1 Sampling

13.1.1.1 The six (6) 12 in. x 12 in. specimens shall be prepared with three (3) in the machine direction and three (3) in the cross-machine direction of the roll.

13.1.2 Conditions of Acceptance

13.1.2.1 Do not subject the aged specimens to “tests in accordance with Section III A, D and E.” Water ponding tests (“Section III D”) and peel-adhesion tests (“Section III E”) are not requirements of this Protocol. The noted “Section III A” shall be addressed in Section 13.1.3 of this Protocol.

13.1.3 Breaking strength and elongation tests of aged specimens shall be conducted in accordance with

Section 9 of this Protocol, except as noted below.

13.1.3.1 Sampling - After the six (6) 12 in. x 12 in. aged specimens have been examined for visible damage, prepare ten (10) 1 in. x 6 in. specimens from the aged material; five in the machine direction and five in the cross-machine direction of the roll. In addition to these ten aged specimens, prepare ten 'as received' specimens of the same dimensions; five in the machine direction and five in the cross-machine direction of the roll.

13.1.3.2 Conditioning - No further conditioning is to be incurred on the aged specimens.

13.1.3.3 Procedure - Each set of samples, as specified in 13.1.3.1 herein, shall be tested 'as received' and after accelerated aging.

13.1.3.4 Report

13.1.3.4.1 Breaking strength shall be reported, in lbf/inch of width, for all test specimens and shall be itemized in grouping of 'as received' and after accelerated aging. These grouping shall be itemized in subgroups of machine direction and cross-machine direction. Any aged specimen which exhibits a breaking strength less than 85% of the 'as received' value shall be considered as failing the accelerated aging test.

13.1.3.4.2 Elongation shall be reported, in (%), for all test specimens and shall be itemized in grouping of 'as received' and after accelerated aging. These grouping shall be itemized in subgroups of machine direction and cross-machine direction. Any aged specimen which exhibits an elongation value greater than 85% of the 'as received' value shall be considered as failing the accelerated aging test.

14. Cyclic Elongation

14.1 This test covers the determination of the cyclic elongation performance of materials specified in Section 1 of this Protocol in accordance with the ICBO Acceptance Criteria For Roof Underlayment For Use In Severe Climate Areas (Section IV F), except as noted below.

14.1.1 Specimens shall be nailed, using four (4) 10d roofing nails, with one nail in each exterior corner of the two pieces of plywood sheathing.

14.1.2 The three specimens shall be prepared with $^{32}/_{16}$ $^{15}/_{32}$ in. x 3 in. x 6 in. APA span rated sheathing.

14.1.3 Any test specimen which exhibits cracking of material shall be considered as failing the cyclic elongation test.

15. Water Vapor Transmission

15.1 This test covers the determination of the water vapor transmission of materials specified in Section 1 of this Protocol in accordance with ASTM Test Method E 96.

15.2 The water vapor transmission of the membrane shall not be greater than 1.0 g/m^2 in 24 hours.

16. Puncture Resistance

16.1 This test covers the determination of the puncture resistance of materials specified in Section 1 of this Protocol in accordance with the ICBO Acceptance Criteria For Concrete Tile Underlayment On Spaced Sheathing (Section 5.0, d,2), except as noted below.

16.1.1 Two 12 in. x 25 in. specimens shall be prepared; one ultraviolet light conditioned and one accelerated aging conditioned, as specified in Sections 12 and 13 of this Protocol, respectively.

16.1.2 Any test specimen which exhibits any sign of puncture shall be considered as failing the puncture test.

17. Slippage Resistance

17.1 Prepare three (3) 4 foot wide x 8 foot long specimens with a 4 inch overlap seam across the center of the 8 foot length. Prepare the specimens: one from one edge of the roll and one from the center of the roll. The length of each specimen should be in the 'machine direction' of the roll.

17.2 The substrate shall be $^{32}/_{16}$ $^{15}/_{32}$ in. x 4' x 8' APA span rated sheathing that has been reinforced on the back side with two angle irons.

17.3 Nail the underlayment to the substrate through 'tin caps,' not less than 1$^5/_8$ in. and not more than 2 in. in diameter and of not less than 32 gage (0.010 in.) sheet metal, using 10d roofing nails, in a grid pattern of 12 in. with 6 in. spacing at the lap, penetrating the sheathing a minimum of $^1/_2$ inch.

17.4 Condition each test deck in an oven maintained at 165 ± 5°F for a minimum of four (4) hours. Thereafter, the deck shall be cooled for three hours at 75° ± 5°F.

17.5 After conditioning, position one test deck at a slope of 4 in:12 in.; one at 5 in:12 in. and the third at a slope of 6 in:12 in.. A 5 in:12 in. test deck may be omitted if requested by the client.

17.6 Onto each sloped test deck, place one (1) stack of 10 flat concrete tiles and one (1) stack of 10 clay tiles equipped with 'lugs,' at the center of each underlayment piece, equidistant from the edge and the seam, to simulate actual loading conditions. Allow the tile stacks to sit on the underlayment surface for 72 hours while maintaining a controlled ambient temperature of 165° ± 5° F.

17.7 Report any tears, slippage or 'tear drop' conditions which arise at fastener penetrations during the test. Report any tile sliding which has damaged any portion of the top surface of the underlayment.

17.8 Any test specimen which exhibits conditions noted in Section 17.7 of this Protocol shall be considered as failing the tile slippage resistance test.

17.9 Provide before and after photographs of each specimen in the final test report.

FOR MINERAL SURFACED ROLL MATERIALS TO BE USED AS A MORTAR SET TILE UNDERLAYMENT

18. Granule Adhesion

18.1 This test covers the determination of granule loss of materials specified in Section 1 of this Protocol, which employ a granular surfacing on one side, in accordance with ASTM Test Method D 5147, Section 14, except as noted below.

18.1.1 Any test specimen which exhibits an average granule loss greater than 0.75 grams shall be considered as failing the granule adhesion test.

TESTING APPLICATION STANDARD (TAS) No. 105-98

TEST PROCEDURE FOR FIELD WITHDRAWAL RESISTANCE TESTING

1. Scope

1.1 This Testing Application Standard (TAS) covers procedures for withdrawal resistance testing of fasteners used for attachment of various components to various substrate materials.

1.2 All testing shall be conducted by an approved testing agency, and all test reports shall be signed by a Professional Engineer or Registered Roof Consultant.

2. Definitions

2.1 For definitions of terms used in this application standard, refer to ASTM D 1079; Chapters 2, & 15 of the *Florida Building Code, Building*.

3. Referenced Documents

3.1 Testing Application Standard TAS 105 Appendix A, Field Withdrawal Resistance Test Results Report.

4. Terminology & Units

4.1 Initial Failure: The point at which the recorded load decreases by 5% or more of the most recent, highest reading.

4.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

5. Significance and Use

5.1 The test procedures outlined in this TAS provide a means of determining whether a particular mechanical fastener, when used to attach any Roofing Component to a specific substrate, provides sufficient resistance to static uplift force to meet the wind-load requirements of this code for a specific building.

6. Apparatus

6.1 Insulation and Membrane Attachment Testing

6.1.1 The test apparatus shall consist of a hydraulic or mechanically operated dynamometer ('pull-tester') fitted with a hydraulic gauge cell to measure force. The resulting force shall be recorded on a digital or analog gauge. For anchor or base sheet fasteners (commonly referred to as 'base ply' fasteners) and other fastener anchors with an anticipated withdrawal resistance less than 100 lbf., the tester and test procedure shall be in compliance with the requirements set forth in this TAS.

6.1.2 Hydraulic dynamometers shall be operated by a screw or pump handle or shall be automatically rising at 2 in. (50 mm) + 0.1 in. per minute for steel and wood decks and $^1/_2$ in. (12.5 mm) + 0.1 in. per minute for concrete, gypsum and cementitious wood fiber decks.

6.2 Anchor or Base Sheet Attachment Testing

6.2.1 The test apparatus shall consist of a minimum $3^1/_2$ in. x $3^1/_2$ in. octagon nylon mesh or 15 mil coated polyester fabric test pad, with a center hole through which the fastener is driven into the deck. The internal hole shall be of sufficient size to allow the fastener legs to pass through without touching the test pad.

6.2.2 The test pad shall be reinforced where attached to the dynamometer to resist tearing.

6.2.3 The dynamometer shall be hydraulic or mechanical and shall be fitted with a hydraulic gauge cell. The resulting force shall be recorded on a digital or analog gauge. The dynamometer shall automatically rise at $^1/_2$ in. (12.5 mm) + 0.1 in. per minute for lightweight concrete, gypsum and cementitious wood fiber testing and 2 in. (50 mm) + 0.1 in. per minute for all other nailable deck types.

6.3 Hydraulic dynamometers ('pull-testers') shall be calibrated within three (3) months prior to conducting the test procedures outlined in this TAS. Facsimiles of the calibration shall be kept with the tester for examination by the authority having jurisdiction, upon request. A copy of the calibration certificate shall be attached to each test report. Calibration shall be in compliance with ASTM E 74, Grade B.

7. Test Limitations and Precautions

7.1 This TAS may involve hazardous operations and equipment. This TAS does not address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

8. Test Procedure for Anchor or Base Sheet, Insulation, and Membrane Attachment testing

8.1 On roof decks of 100 squares or less, ten (10) withdrawal resistance tests shall be conducted, not less than three (3) of which shall be in the perimeter areas (2), three (3) in corner areas (3), the remainders in the field areas (1) as defined in ASCE 7.

8.2 For every additional 50 squares, an additional three (3) withdrawal resistance tests shall be conducted. (This ratio of 50:3 shall be maintained with each additional increase in samples.)

8.3 The number of test samples required in shall be increased by 125% for all gypsum, lightweight insulating concrete and cementitious wood fiber deck types.

8.4 Testing shall also take place in any low areas that are, or may be, subjected to ponding water. All such areas shall be noted on a roof plan attached to the final test report.

8.5 If more than one deck type is on a single roof area, each deck type shall be treated as a separate roof area.

8.6 Stair towers, mechanical penthouses and mechanical rooms shall have a minimum of four (4) withdrawal resistance tests, two of which shall be taken at perimeter areas 2 & 3, as defined in ASCE 7.

9. Calculations

9.1 Mean Failure Load ($\overline{F}$) and Sample Standard Deviation

9.1.1 Determine the mean failure load ($\overline{F}$) and sample standard deviation (S_F) using tabulated data and the following equations.

$$\overline{F} = \frac{1}{N}\sum_{i=1}^{N} F_i \qquad \text{and,}$$

$$S_F = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(F_i - \overline{F}\right)^2} \qquad \text{where,}$$

F = mean failure load (lbf);

S_F = sample standard deviation (lbf);

N = total number of pulls;

F_i = recorded failure load on pull number i; and,

i = 1, 2, 3, ..., N = pull number

9.2 Minimum Characteristic Resistance Force (F')

9.2.1 Determine the minimum characteristic resistance force (F') using the following equation.

$$F' = \overline{F} - t_{v,p} x \left(\frac{S_F}{\sqrt{S_F}}\right)$$

where,

F' = minimum characteristic resistance force (lbf);

$\overline{F}$ = mean failure load (lbf);

t_{Qp} = t-estimator based on 95% precision level;

v = degrees of freedom = (N-1);

P = probability level = 95%; and,

S_F = sample standard deviation.

9.2.1.1 The t-estimator noted above is a function of probability (P) and degrees of freedom (v). Values for a 95% probability level are noted in Table 1, below.

TABLE 1
VALUES FOR T-ESTIMATOR AT 95% PROBABILITY

DEGREES OF FREEDOM (v)	t_v95
9	2.26
10	2.23
11	2.20
12	2.18
13	2.16
14	2.15
15	2.13
16	2.12
17	2.11
18	2.10
19	2.09
20	2.09
21	2.08
22	2.07
23	2.07
24	2.06
25	2.06
26	2.06
27	2.05
28	2.05
29	2.05
30	2.04
40	2.02
60	2.00

1 degrees of freedom is equal to the number of pulls minus one (v = N - 1)

10. Report

10.1 The final test report shall include the following items:

10.1.1 Certification of dynamometer ('pull-tester') calibration within three (3) months prior to conducting the test, including calibration data.

10.1.2 The final test report shall be signed and sealed by a Professional Engineer or Registered Roof Consultant.

10.1.3 A description of the name, location, height, dimensions and deck type(s) and/or substrate type(s) of the building on which the test is being conducted.

10.1.4 The fastener type and manufacturer and a description of the Roofing Component which the fastener is intended to secure.

10.1.5 The number of withdrawal resistance tests; the tabulated test results; and a statistical analysis of the raw data, including the mean failure load; the sample standard deviation; and the minimum characteristic resistance force.

10.1.6 If a hole is pre-drilled, data on the size and type of bit shall be included together with the depth of the hole and the type of equipment used to pre-drill.

10.1.7 If the fastener is self-drilling, include the type and speed of the installation tool. Literature on the fastening device shall be attached to the test report.

10.1.8 Failure of the fastener shall be recorded at 'initial failure load.' The ultimate failure load (the greatest resistance to pullout recorded prior to withdrawal) shall not be recorded.

10.1.9 Indicate on a roof plan the locations where all withdrawal resistance tests were taken with an 'identifier' and include the 'identifier' with the data submitted.

TESTING APPLICATION STANDARD (TAS) 105-98

APPENDIX A
FIELD WITHDRAWAL RESISTANCE TEST RESULTS REPORT

GENERAL INFORMATION:

Job Name: ____________________

Job Address: ____________________

____

Contact Individual at job site (if any): ____________________

TESTING AGENCY/EQUIPMENT INFORMATION:

Note: The undersigned acknowledges that all testing has been conducted and results have been reported in compliance with TAS 105 or TAS 105 Appendix A.

Testing Agency Name: ____________________

Address: ____________________

____

Telephone: (_____) - _______ - ________

Fax: (_____) - _______ - ________

Representative Name: ____________________

Title: ____________________

Signature: ____________________

Test Apparatus (General Description):

____

____

____

BUILDING/ROOF SYSTEM INFORMATION: **Area No.** ______

Roof Area Height: height = ______ ft

Roof Area Dimensions: length = ______ ft

second largest dimension = ______ ft

total roof area = ______ ft^2

= ______ sqs.

perimeter area = ______ ft^2

(see RAS 117)

BUILDING/ROOF SYSTEM INFORMATION: **Area No.** ______

Roof Area Height: height = ______ ft

Roof Area Dimensions: length = ______ ft

second largest dimension = ______ ft

total roof area = ______ ft^2

= ______ sqs.

perimeter area = ______ ft^2

(see RAS 117)

BUILDING/ROOF SYSTEM INFORMATION: **Area No.** ______

Roof Area Height: height = ______ ft

Roof Area Dimensions: length = ______ ft

second largest dimension = ______ ft

total roof area = ______ ft^2

= ______ sqs.

perimeter area = ______ ft^2

(see RAS 117)

Note: **If more than three roof areas are tested, attach additional page(s) having this format to identify all roof areas.**

FASTENER INSTALLATION INFORMATION:

Is the fastener a self-driller? yes no

If yes, list the type of tool used for fastener installation:

____

Speed of Tool: ________ rpm's

TEST INFORMATION:

Number of Tests Conducted: n = ______

- *See Section 8 of TAS 105*
- *Note the location of all tests on 'Building Information' Detail #2, attached.*

FIELD WITHDRAWAL RESISTANCE TEST RECORDING SHEET

Area No. ________

(Refer to deck dimensions referenced on page __)

Component to be secured:

Insulation

Membrane

Anchor or Base Sheet

Woodblocking

Metal Profiles

Fastener Type: ________

Fastener Manufacturer: ________

Pre-drilled? Yes ___ No ___

If Yes: Drill bit size: ________ " dia.

Hole Depth: ________ "

See Section 8 to determine number of tests (If drill bit is high tolerance, include range in $^{1}/_{1000}$" tolerances)

SAMPLE NO.	PLAN IDENTIFIER	INITIAL FAILURE LOAD (lbf)	FIELD PERIMETER OR CORNER ARE (circle one)		
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C
			F	P	C

STATISTICAL ANALYSIS:

Mean Failure Load: F = ___________ lbf

Sample Standard Deviation: S_F = ___________ lbf

Minimum-Characteristic Resistance Force: F' = ___________ lbf

Notes:

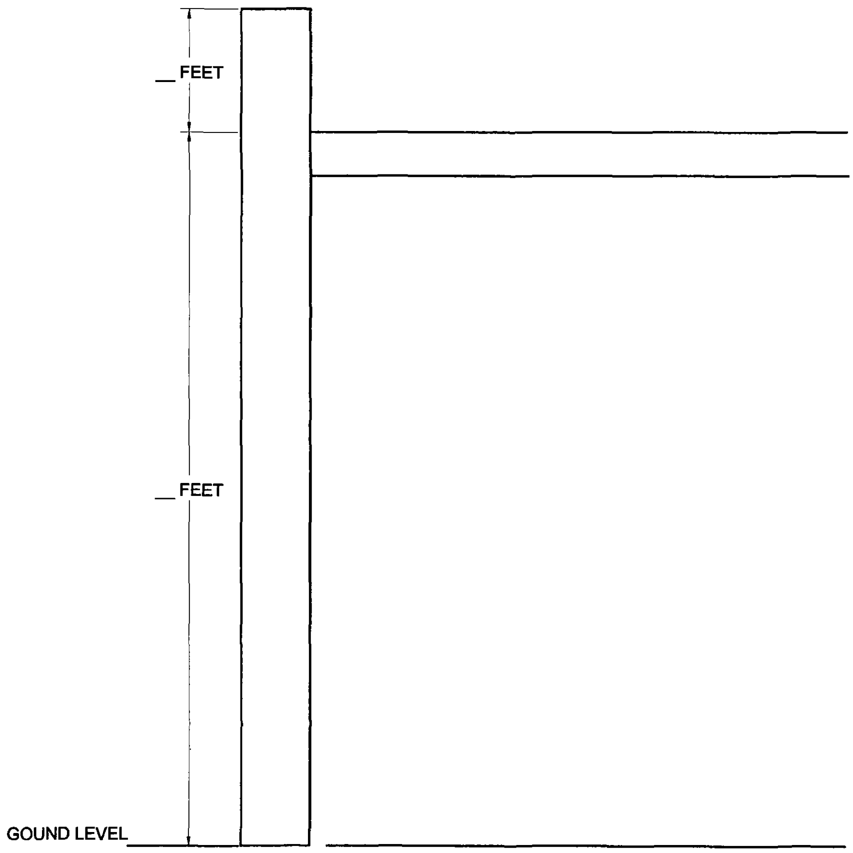
1. **Use of the results herein to determine the required number of fasteners for insulation attachment or an acceptable anchor or base sheet fastener spacing, as outlined in TAS 117, shall utilize the minimum characteristic resistance force (F'), determined in compliance with Section 9 of TAS 105. No margin of safety shall be applied to field withdrawal resistance test results determined in compliance with TAS 105.**
2. **A safety factor of 2 to 1 shall be applied to all results of laboratory testing.**
3. **The following pages shall be completed for each roof area and included with all Field Withdrawal Resistance Test Recording Sheets.**

Notes: ____

____

____

ROOF AREA NO. _______
INSERT BUILDING AND PARAPET HEIGHTS.
(IF NO PARAPET EXISTS, INSERT "N/A")



TESTING APPLICATION STANDARD (TAS) No. 106

STANDARD PROCEDURE FOR FIELD VERIFICATION OF THE BONDING OF MORTAR OR ADHESIVE SET TILE SYSTEMS AND MECHANICALLY ATTACHED, RIGID, DISCONTINUOUS ROOF SYSTEMS.

1. Scope

1.1. This Application Standard is a product application quality control test to confirm: 1) sufficient bonding by the mortar or adhesive to the tile and underlayment in a mortar or adhesive set tile system; or 2) effective mechanical attachment of components within a rigid discontinuous roof system.

2. Definitions

2.1 For definitions of terms used in this application standard, refer to ASTM D 1079; and the *Florida Building Code, Building*.

3. Requirements

3.1 All field verification and testing shall be performed by a Dade County Approved Testing Agency. All reports, tests, and calculations shall be in compliance with TAS 301.

3.2 A minimum of 97% of the roofing tile physically inspected shall be determined to be fully bonded.

3.3 A minimum static test uplift load of not less than 35 lbf. per tile shall be applied for mortar or adhesive set tile systems.

3.4 For mechanically attached, rigid discontinuous systems, a minimum static test uplift load of not less than 80% of the resistance load (F') or (Mr') as listed in the manufacturer's Product Approval shall be applied.

4. Procedure

4.1 Examine the entire area of the roof for loose tile by lifting any tile by hand or with a hand held griping device. Physically examine not less than one (1) tile in ten (10) of all components in the field area and one (1) tile in five (5) of all tile in perimeter and corner areas including hip and ridge tile.

4.1.1 Mark each physically tested tile in the field and record all loose tile observed.

4.1.2 If more than 3% of the tile in any roof area arc determined to be loose. No further testing shall be conducted and the Roof System shall be considered to have failed the testing and be unacceptable.

4.1.3 If less than 3% of the tile in any roof area are determined to be loose static up lift tests shall be performed.

4.1.4 Mark all tested tile with a "T" using a waterproof marker.

5. Apparatus

5.1.1 The test apparatus shall consist of a hook shaped to a 90 degree angle, or other load transfer device capable of sliding underneath the nose of the tile and remaining in place as the loads are applied. The hook or other device shall have sufficient strength to resist applied loads of at least 100 lbf.

5.1.2 The hook- or other load transfer device shall be attached to a cable fitted with a load cell with a dial or digital indicator, which displays the load within 0.1 lbf.

6. General

6.1 The number of tiles which shall be tested in the field, perimeter and comer areas of the roof shall be as follows:

6.1.1 For roof areas less than 5 squares, one (1) uplift test is required.

6.1.2 For roof areas five (5) squares or more a minimum of one (1) test per every two (2) squares in the field: one (1) test per square in the perimeter area and (1) in the corner areas including one (1) test per every twenty (20) hip and ridge tiles.

7. Load Application

7.1 For mortar or adhesive set tile systems. The operator shall apply an even load by lifting up on the handle until the load cell indicator register 35.0 ± 5 lbf. The load shall be held for 5 seconds.

7.1.1 This test shall be carried out on all mortar and adhesive set applications after final completion of the application at a time as stated in the Product Approval or as specifically approved by the manufacturer of the mortar/adhesive.

7.1.2 For mechanically attached systems, determine the load to be applied by multiplying the minimum characteristic resistance load (F′) or (Mr’), listed in the Product Approval by 0. 80. The operator shall apply this load by lifting up on the handle until the load cell indicator registers the magnitude of this load ± 5%. The load shall be held for 5 seconds.

8. Recorded Data shall include the following observations

8.1.1 Tile breaks or cracks.

8.1.2 Mortar patty or adhesive separates from the underlayment.

8.1.3 Tile separates form the adhesive or mortar.

8.1.4 The nose of the tile deflects vertically in excess of 2 inches in mechanically attached systems.

9. Acceptance Criteria

9.1.1 75% or more of the static up lift tests shall be required to pass the testing criteria.

10. Report

10.1 The final test report shall include the following:

10.1.1 A sketch of the test site roof which indicates 1) the field, perimeter and corner areas, with dimensions; and, 2) the location of all components on which a static uplift test is conducted. Indicate those attachments which were initially tested and, if applicable, those attachments which were tested in the extended testing.

10.1.2 A tabulated set of test results, signed by a Professional Engineer or a Registered Roof Consultant.

TESTING APPLICATION STANDARD (TAS) No. 107-95

TEST PROCEDURE FOR WIND RESISTANCE TESTING OF NON-RIGID, DISCONTINUOUS ROOF SYSTEM ASSEMBLIES (Modified from ASTM D 3161)

1. Scope

1.1 This test method covers the determination of the resistance to wind blow-up or blow-off of asphalt shingles, metal shingles or other non-rigid, discontinuous Roof System Assemblies when installed in compliance with the manufacturer's current, published installation instructions.

2. Referenced Documents

2.1 *ASTM Standards*

D 3161 Standard Test Method for Wind Resistance of Asphalt Shingles.

E 380 Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.2 *The Florida Building Code, Building.*

2.3 *Roof Consultants Institute* Glossary of Terms

3. Terminology & Units

3.1 Definitions- For definitions of terms used in this specification refer to ASTM D 3161; and/or Chapters 2 and 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*; and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Types of Roof System Assemblies

4.1 Asphalt shingles are of two types:

4.1.1 *Type I* - Shingles with a factory-applied adhesive (self-sealing shingles).

4.1.2 *Type II* - Shingles of the lock-type, with mechanically interlocking tabs or ears.

4.2 Metal shingles or other non-rigid, discontinuous Roof System Assemblies shall be tested under this Protocol at the direction of the Authority Having Jurisdiction.

5. Significance and Use

5.1 Asphalt shingles, metal shingles or other non-rigid, discontinuous Roof System Assemblies that have demonstrated wind resistance by this test have also performed well in use. Local wind conditions may differ from the test conditions both in intensity and duration, and should be taken into consideration. This method is suitable for use in specifications and regulatory statutes. This method, assisted by experience and engineering judgment, will also prove useful for development work.

6. Test Limitations and Precautions

6.1 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Apparatus

7.1 Test Machine

7.1.1 The 'test machine' shall be capable of delivering a horizontal stream of air through a rectangular opening, 36 in. (914 mm) wide and 12 in. (305 mm) high, at a velocity of 110 mph (177 km/h) ± 5% as measured at the orifice.

7.1.2 The 'test machine' shall be equipped with an adjustable stand on which a test panel is placed. The stand shall be adjustable to setting the test panel at any desired slope, at any horizontal distance from the lower edge of the duct opening, and at various angles incident to the wind direction.

7.2 Clock

7.3 Mechanical Circulation Conditioning Cell or Room

7.3.1 A mechanical circulation conditioning cell or room with a forced air circulation shall be utilized for self-sealing shingle conditioning. The cell or room shall be capable of receiving a minimum 50 in. (1.27 m) wide by 66 in. (1.68 m) long test panel at a slope of 2 in:12 in. and of maintaining a uniform temperature of 135 to 140°F (57 to 60°C).

8. Test Specimen

8.1 Deck

8.1.1 The wood test deck shall consist of APA 32/16 span rated sheathing of $^{15}/_{32}$ in. thickness and not less than 50 in. by 66 in. (1.27 m by 1.68 m) in dimension. The wood test deck shall be of such rigidity that it will not twist or distort with normal handling, or vibrate from the wind velocity during the test.

8.2 Underlayment

8.2.1 Underlayment shall be two layers of 15 lb ASTM D 226, type I asphalt saturated felt mechanically attached to the wood test deck, with 12 ga. roofing nails and $1^5/_8$ in. tin caps, in a 12 in. grid pattern staggered in two rows in the field and 6 in. o.c. attachment at any laps.

8.3 Self-Sealing Asphalt Shingles

8.3.1 Apply self-sealing asphalt shingles to duplicate test decks, parallel to the short dimension of the test deck, in compliance with the manufacturer's instructions.

8.3.2 Asphalt shingles shall be attached using 12 ga. roofing nails, properly positioned in compliance with the manufacturer's instructions, to fasten each shingle. No cement, other than the factory-applied adhesive, shall be used to fasten down the tabs. Do not apply pressure to the shingle tabs either during or after application.

8.4 Lock-Type Asphalt Shingles

8.4.1 Apply lock-type asphalt shingles to not less than four test decks, parallel to the short dimension of the panel, in compliance with the manufacturer's instructions. Secure the shingles at the outer edge of the test panel by exposed nailing to simulate anchoring at the rake edges of a roof deck.

8.5 Metal Shingles or Other

8.5.1 Apply metal shingles or other non-rigid, discontinuous components to duplicate test decks, parallel to the short dimension of the test deck, in compliance with the manufacturer's instructions.

8.6 Control the temperature at 80 ± 15°F (27 ± 8°C) and maintain the slope of the panel at 2 in:12 in. (17% slope) during shingle application.

9. Conditioning

9.1 Maintain the test specimens at a slope of 2 in:12 in. and at a temperature of 80 ± 15°F (27 + 8° C) until the commencement of heat conditioning.

9.2 Place the test specimens in the conditioning cell or room at a slope of 2 in:12 in. and maintain at a temperature of 135 to 140°F (57 to 60°C) for a continuous 16 hour period.

9.3 After completion of the conditioning period, allow the test specimens to come to room temperature [80 ± 15°F (27 ± 8°C)] while at a slope of 2 in:12 in.

9.4 Exercise care to avoid pressure on shingle tabs by any twisting or distortion of the test specimens during handling.

10. Procedure

10.1 Location of the Test Panel

10.1.1 Install the test specimen on the test carriage and adjust it in relation to the duct such that the exposed edge of the target course is on the same level as the lower edge of the duct orifice at a horizontal distance of 7 in. ± $^1/_{16}$ in. (178 ± 1 mm). The target course shall be the third course up from the bottom of the test specimen. The test incline shall be 2:12 in. for self-sealing shingles, and at the lowest incline recommended by the manufacturer for lock-type asphalt and metal shingles and other non-rigid, discontinuous systems.

10.1.2 Since the design of lock-type shingle may make it difficult to determine the most critical angle of wind direction, conduct the test at a minimum of three different angles: 1) head-on; 2) with the bottom of the target course parallel to and 7 in. (178 mm) away from the machine orifice; and, 3) with the test specimen rotated 30 and 60 degrees from the head-on position, with the bottom corner of the third-course tab nearest to the duct being 7 in. (178 mm) away from and in the same horizontal plane as the bottom of the machine orifice. Test another panel at the position judged to be most critical on the basis of the first three tests.

10.2 Performing the Test

10.2.1 Maintain the ambient temperature at 75 ± 5°F (24 + 3°C) during the wind tests.

10.2.2 As soon as the test specimen is set in position, start the fan, adjust to produce a velocity of 110 mph (177 km/hr) ± 5% at the orifice, and maintain continuously for 2 hours, or until such lesser time as a failure occurs.

10.2.3 During the test, an observer shall note any lifting of shingle tabs or non-rigid components and shall record any damage to a full shingle or non-rigid component or the disengaging of a locking ear or tab, or a shingle tab, including any failure of adhesive. The time at which any of these 'failures' occur shall be noted.

10.2.4 If failure occurs during the test, stop the air flow and record the exposure time. The end point for failure shall be taken as the time at which the sealing feature fails to restrain one or more full shingle tabs, or a locking ear or tab of a lock shingle tears loose or disengages from its locking position or a non-rigid component is damaged so as to affect the performance of the system. In addition, no free portion of a shingle or non-rigid component shall lift so as to stand upright or bend back on itself during the test.

11. Certification

11.1 A test report will be provided to the Chief Code Compliance Officer confirming successful compliance with the test provisions of this Protocol. Completion of this test Protocol is one in a series of Testing Application Standards required by the *Florida Building Code, Building* for Product Approval of non-rigid, discontinuous Roof System Assemblies.

TESTING APPLICATION STANDARD (TAS) No. 108-95

TEST PROCEDURE FOR WIND TUNNEL TESTING OF AIR PERMEABLE, RIGID, DISCONTINUOUS ROOF SYSTEMS

1. Scope:

1.1 This protocol covers procedures for determining the wind characteristics of an air permeable, rigid, discontinuous roof system. The test procedures herein provide the pressure distribution occurring, at various wind speeds, on the top and bottom surfaces of an instrumented component within a test specimen consisting of a wood deck; underlayment; and, an air permeable, rigid, discontinuous roof system. The calculations herein determine the coefficients of pressure (C_P) along the top and bottom surfaces of the instrumented component; the coefficient of lift (C_L); the coefficient of moment (C_{Ma}); and the aerodynamic multiplier (l) for the instrumented component.

NOTE: The coefficient of lift (C_L) need only be determined for 'S' shaped clay or concrete tile systems. In addition, the coefficient of moment (C_{Ma}) need not be determined for 'S' shaped clay or concrete tile systems. This is discussed further in Section 10.5.

1.2 The aerodynamic multiplier (l), determined under this protocol, is used to determine the attachment resistance (M_f) required for the particular type of system installed on a particular building in the high-velocity hurricane zone jurisdiction, in compliance with the attachment calculations set forth in RAS 127 and the wind load requirements set forth in Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building.*

2. Referenced Documents:

2.1 *The Florida Building Code, Building.*

2.2 *Application Standards:*

TAS 101	Test Procedure for Static Uplift Testing of Mortar or Adhesive Set Tile Systems
TAS 102	Test Procedure for Static Uplift Testing of Mechanically Attached, Rigid Roof Systems
TAS 102(A)	Test Procedure for Static Uplift Testing of Clipped, Rigid Roof Systems
TAS 116	Test Procedure for Air Permeability Testing of Rigid, Discontinuous Roof Systems

2.3 *Redland Technology - New Technology & Product Development Centre* Fixing Studies for MRTI Normal Weight Tiles - SBCCI Submission

2.4 *ASTM Standards:*

E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.5 *Roof Consultants Institute:*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions–For definitions of terms in this protocol, refer to Chapters 2 and Section 1513 of the *Florida Building Code, Building*; and/or Fixing Studies for MRTI Normal Weight Tiles; and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 Use of this protocol is limited to systems which are air permeable, as determined in compliance with TAS 116 or deemed air permeable by the chief code compliance officer, in which the unsealed, overlapping, rigid components have a length between 1.0 and 1.75 feet; an exposed width between 0.73 and 1.25 feet; and a thickness not greater than 1.3 in.

Note: The Chief Code Compliance Officer may waive the requirement for air permeability testing in compliance with TAS 116.

4.2 The procedures outlined in this protocol provide a means of determining the aerodynamic multiplier (l) for the air permeable, rigid, discontinuous roof system being tested. This aerodynamic multiplier (l) shall be listed in the system manufacturer's Product Approval for use in RAS 127, in combination with the rigid component's restoring moment due to gravity (M_g), determined in compliance with TAS 101 for mortar or adhesive set tile systems; TAS 102 for mechanically attached, rigid, discontinuous roof systems; TAS 102(A) for mechanically attached systems accompanied by a clip; and the wind load requirements set forth in Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*.

5. Apparatus:

5.1 The wind tunnel:

5.1.1 The wind tunnel shall be an open circuit wind tunnel capable of producing wind speeds up to 110 miles per hour. If the wind tunnel is unable to produce wind speeds of this magnitude, a wind constrictor of appropriate size shall be utilized to generate such wind speeds. The wind constrictor shall be fully sealed to around the edges to prevent air leakage. (See Figure 1, attached.)

5.1.2 A plenum chamber shall be located below area B of the test specimen, as noted in Figure 2, attached, to simulate an internal coefficient of pressure of + 0.25.

6. Precautions:

6.1 This protocol may involve hazardous materials, operations and equipment. This protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Test Specimen—the test specimen shall be constructed within the wind tunnel to avoid possible damage which may occur during transport.

7.1 Deck:

7.1.1 The wood deck sheathing shall be APA $^{32}/_{16}$ span rated sheathing of $^{15}/_{32}$ inch thickness, attached with 8d common nails at 6 inches o.c. at panel edges and 12 inches o.c. at intermediate supports. One transverse joint shall be included to simulate the potential for air leakage from below.

7.2 Underlayment

7.2.1 The underlayment shall be a standard 30/90 system with a 30 ASTM D 226, type II anchor sheet and an ASTM D 249 mineral surface roll roofing as the top ply.

7.2.2 The anchor sheet shall be mechanically attached to the wood sheathing, with 12 ga. roofing nails and $1^5/_8$ inch tin caps, in a 12 inch grid pattern staggered in two rows in the field and 6 inches o.c. at any laps. The mineral surface top ply shall be applied in a full mopping of ASTM D 312, type IV asphalt.

7.2.3 The underlayment edges shall be set in adhesive to provide an airtight, continuous seal around the perimeter of the test deck.

7.3 Area A, noted in Figure 2, shall be used to provide the boundary conditions for the air flow over Area B. The rigid components in Area A shall be rigidly attached to the substrate and shall extend not less than four courses. The rigid components in Area B shall be attached or bonded in compliance with the manufacturer's published installation instructions and shall extend not less than five courses. The width of the test specimen shall be not less than four laid components.

7.4 Mortar set tile systems:

7.4.1 Mortar mix shall have a roofing component product approval for use with the mortar set tile system and shall be in compliance with TAS 123.

7.4.2 Mortar shall be mixed using the mixing ratio specified in the mortar manufacturer's Product Approval.

7.4.3 Mortar flow shall be determined using a cone penetrometer test, in compliance with ASTM C 780 (Appendix A1), the results of which shall be $2^1/_8 + ^1/_8$ inch (55 + 3 mm) of penetration.

7.4.4 Mortar set tile shall be applied in a bed of mortar, the amount of which shall be a 10 inch trowel filled with mortar. The 10 inch trowel shall be placed at the same location beneath each tile on the test specimen with the exception of the instrumented tile noted in Section 7.9, herein.

7.4.5 Mortar set tile systems shall be allowed to cure at ambient conditions for a period of 24 hours prior to conducting the wind tunnel test.

7.5 Adhesive Set Tile Systems:

7.5.1 Adhesive shall have a roofing component product approval for use with the adhesive set tile system which is being tested and shall be applied in compliance with the provisions set forth in that approval.

7.5.2 Adhesive set tile systems shall be allowed to cure for a period of 24 hours prior to conducting the wind tunnel test.

7.6 Mechanically Attached, Rigid, Discontinuous Roof Systems

7.6.1 Each component shall be installed in compliance with the system manufacturer's published installation instructions; the current Product Approval; and/or the minimum requirements set forth in Chapter 15 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building*. The requirements of the *Florida Building Code, Building* shall take precedence.

7.6.2 Component attachment fasteners (i.e. nails, screws, tile straps, etc.) shall be those recommended by the system manufacturer's published installation instructions. Nails shall be not less than 0.109 inch in diameter and minimum screws shall be #8 diameter screw fasteners. Component attachment fasteners shall meet the corrosion requirements set forth in TAS 114, Appendix E.

7.6.3 Battens (if applicable):

7.6.3.1 Horizontal batten system

- Horizontal battens shall be of nominal 1 inch by 2 inch dimensional lumber and shall be spaced to provide a minimum 3 inch head lap, or to match the interlocking configuration of the component's profile.
- Apply one $^1/_4$ inch bead of approved sealant to the underside of horizontal battens and attach to the test deck at 6 inches o.c. using 12 ga. roofing nails, ensuring each nail penetrates the sealant bead.

7.6.3.2 Counter batten system

- Vertical battens shall be nominal 1 inch by 4 inch lumber and shall be spaced 24 inches over the intermediate supports (trusses).
- Apply one $^1/_4$ inch bead of approved sealant to the underside of vertical battens and attach to the test deck at 6 inches o.c. using 12 ga. roofing nails.
- Horizontal battens (counter battens) shall be as noted in Section7.6.3.1, nailed to the 1

inch by 4 inch vertical battens using 12 ga. roofing nails of sufficient length to penetrate both battens.

7.7 Pressure Measurement, Top Surface

7.7.1 One component, located in the center of Area B, shall be instrumented with 20 pressure tappings (i.e. 20 holes drilled through the body and along the centerline of the component). The first 10 pressure tappings shall be equally spaced, toward the nose of the component, within the first $^1/_3$ of the component's length. The remaining 10 pressure tappings shall be equally spaced within the remaining $^2/_3$ of the component's length.

7.7.2 The tappings shall be sized to accept tubes which are solidly fixed through the holes at the bottom of the component. The opposite end of the tubes shall be connected to a suitable pressure measuring device which permits sampling of pressures in all 20 tubes. These pressure tappings allow for measurement of the static pressure distribution on the component's top surface.

7.8 Pressure measurement, bottom surface

7.8.1 The instrumented component, noted in Section 7.7, shall also be instrumented with seven (7) similar pressure tubes installed on the bottom surface, parallel along the length of the component. The first 4 pressure tubes shall be equally spaced, toward the nose of the component, within the first $^1/_3$ of the component's length. The remaining 3 pressure tubes shall be equally spaced within the remaining $^2/_3$ of the component's length.

7.8.2 These pressure tubes allow for measurement of the static pressure distribution on the component's bottom surface and shall be connected to a similar pressure measuring device.

7.9 For mortar or adhesive set tile systems, the instrumented tile shall be installed with adhesive applied around the tile perimeter, as close as possible, but without interfering with the pressure tappings. The adhesive shall have similar flow properties to those noted in Section 7.4.3 and shall be applied to simulate the configuration of a typical mortar or adhesive patty.

7.10 All components along the side of the test specimen shall be sealed with adhesive tape to prevent air flow between the underside of the components and the slow moving layer of air on the side walls of the wind tunnel.

7.11 The test specimen shall be inspected by a professional engineer or registered roof Consultant, who shall certify, in the final report, that it was constructed in compliance with the provisions of this protocol.

8. Calibration:

8.1 Pressure tubes:

8.1.1 Each pressure tube from the tapped component shall be checked for leakage by applying a pressure to the tube and clamping it off. Leakage shall be identified by any pressure drop recorded by the pressure measuring device. Any pressure tube which exhibits leakage shall be repaired or replaced.

8.2 Pitot-static tube:

8.2.1 The pitot-static tube shall be cross-checked against a cup anemometer which gives an electrical output.

8.3 Manometer:

8.3.1 The manometer(s) shall be cross-checked against an electrical pressure transducer.

9. Test Procedure:

9.1 Construct the test specimen in testing position in the wind tunnel as noted in Section 7.

9.2 Position the pitot-static tube 4 inches above the test specimen at the junction between Area A and area B. Attach the pitot-static tube to pressure tube connections which allow measurement of the total pressure (p_{total}) and the free stream static pressure (p_∞). The velocity pressure (q) shall be determined by subtracting the free stream static pressure (p_∞) from the total pressure (p_{total}), as noted in Section 10.1.

9.3 Turn the wind generator on and set the pressure in the plenum chamber to reflect an internal pressure coefficient of +0.25.

9.4 Begin air flow over the test specimen at a wind speed of 70 mph, as measured at the pitot-static tube position, and hold until all pressure readings have stabilized. When pressure readings have stabilized, record the pressure readings on the top and bottom surfaces of the instrumented component.

9.5 Increase the wind speed to 80 mph and hold until all pressure readings have stabilized. When pressure readings have stabilized, record the pressure readings on the top and bottom surfaces of the instrumented component. Repeat this procedure in 10 mph increments until a wind speed of 110 mph is reached or until any portion of the test specimen experiences wind related damage.

9.6 Tabulate all of the top and bottom surface pressure readings for each wind speed at which pressure measurements were taken. Any system which experiences wind related damage prior to recording pressure measurements for the 90 mph windspeed shall be considered as a 're-test.'

10. **Calculations**—The following calculations shall be performed for each of the wind speeds at which pressure measurements were taken.

10.1 Velocity Pressure (q)

10.1.1 Determine the velocity pressure (q) incurred over the test specimen by subtracting the free stream static pressure (p_∞) from the total pressure (p_{total}).

$$q = p_{total} - p$$

10.2 Coefficient of pressure (C_P)

10.2.1 Determine the coefficient of pressure for each of the top and bottom pressure tappings, (C_{Pt} and C_{Pb} respectively) using the following equations.

Surface: Bottom Surface:

$$C_{pt} = \frac{P_t - P_\infty}{q} \qquad C_{Pb} = \frac{P_b - P_\infty}{q}$$

where,

C_{Pt} = coefficient of pressure (top surface);

P_t = local pressure on component (top surface);

C_{Pb} = coefficient of pressure (bottom surface);

P_b = local pressure on component (bottom surface);

P_∞ = free stream static pressure; and,

q = velocity pressure

10.3 Coefficient of Lift (C_L) –the coefficient of lift (C_L) need only be determined for 'S' shaped clay or concrete tile systems. This is discussed further in Section 10.5.

10.3.1 Determine the coefficient of lift (C_L) for 'S' shaped clay or concrete tile systems using the coefficients of pressure (C_{Pt} and C_{Pb}) from Section 10.2 and the following equation.

$$C_L = \frac{\sum_0^7 C_{Pb} \times \delta_{barea}}{l \times b} - \frac{\sum_0^{20} C_{Pt} \times \delta_{tarea}}{l \times b}$$

where,

C_L = coefficient of lift;

C_{Pb} = coefficient of pressure (bottom surface;

C_{Pt} = coefficient of pressure (top surface);

δ_{barea} = elemental area at pressure tapping (bottom surface);

δ_{tarea} = elemental area at pressure tapping (top surface);

l = tile length; and

b = tile cover width.

10.3.2 If the variation of C_L values obtained over the wind speed range is no more than 5 percent, then the average value of C_L shall be evaluated and used to determine the aerodynamic multiplier (l), as noted in Section 10.5. If the variation in C_L values is greater than 5 percent, then the value obtained at the highest wind speed shall be utilized.

10.4 Coefficient of Moment (C_{Ma}) –coefficient of moment (C_{Ma}) need not be determined for 'S' shaped clay or concrete tile systems.

10.4.1 Determine the coefficient of moment (C_{Ma}) using the coefficients of pressure (C_{Pt} and C_{Pb}) from 10.2 and the following equation.

$$C_{Ma} = \frac{\sum_{0}^{7} C_{Pb} \times l'_b \times \delta_{barea}}{l^2 \times b} - \frac{\sum_{0}^{20} C_{Pt} \times l'_t \times \delta_{tarea}}{l^2 \times b}$$

where,

C_{Ma} = coefficient of moment;

C_{Pb} = coefficient of pressure (bottom surface;

C_{Pt} = coefficient of pressure (top surface);

δ_{barea} = elemental area at pressure tapping (bottom surface);

δ_{tarea} = elemental area at pressure tapping (top surface);

l_b' = moment arm acting at each pressure tapping (bottom surface);

l_t' = moment arm acting at each pressure tapping (top surface);

l = component length; and

b = component cover width.

10.4.2 If the variation of C_{Ma} values obtained over the wind speed range is no more than 5 percent, then the average value of C_{Ma} shall be evaluated and used to determine the aerodynamic multiplier (l), as noted in Section 10.6. If the variation in C_{Ma} values is greater than 5 percent, then the value obtained at the highest wind speed shall be utilized.

10.5 Aerodynamic multiplier (λ)–(for 'S' shaped clay or concrete tile systems)

10.5.1 Due to the shape and attachment point of 'S' shaped clay or concrete tile, the axis of rotation is different from that of other rigid, discontinuous roof systems and the aerodynamic multiplier (λ) for these tiles must be based on the aerodynamic moment about this axis. For this reason, the coefficient of moment (C'_{Ma}) for such tile systems needs to be an adjusted value (C'_{Ma}) to reflect rotation about this axis.

10.5.2 Determine the adjusted coefficient of moment (C_{Ma}) using the coefficient of lift (C_L) from Section 10.3 and the following equation.

$$C'_{Ma} = C_L \times \frac{0.984}{l}$$ where,

C'_{Ma} = adjusted coefficient of moment;

C_L = coefficient of lift; and

l = tile length.

10.5.3 Determine the aerodynamic multiplier (l) for 'S' shaped clay or concrete tile systems using the adjusted coefficient of moment (C'_{Ma}) from Section 10.5.2 and the following equation.

$$\lambda = C'_{Ma} \times b \times l^2$$ where,

λ = aerodynamic multiplier;

C'_{Ma} = adjusted coefficient of moment;

b = tile cover width; and

l = tile length.

10.5.4 The aerodynamic multiplier (λ) shall be listed in the 'S' shaped clay or concrete tile system manufacturer's Product Approval for reference.

10.6 Aerodynamic Multiplier (λ) - (for all systems other than 'S' shaped clay or concrete tile systems)

10.6.1 Determine the aerodynamic multiplier (λ) for the system using the coefficient of moment (C_{Ma}), from Section 10.4 and the following equation.

λ = $C'_{Ma} \times b \times l^2$ where,

λ = aerodynamic multiplier;

C'_{Ma} = adjusted coefficient of moment;

b = tile cover width; and

l = tile length.

10.6.2 The aerodynamic multiplier (λ) shall be listed in the manufacturer's Product Approval for reference.

11. Report:

11.1 The final report shall include the following:

11.1.1 A description and sketch of the component, including the manufacturer and type of air permeable, rigid, discontinuous roof system.

11.1.2 A detailed report of the test specimen construction, including a photograph of the test specimen and certification by a professional engineer or registered roof consultant that the test specimen was constructed in compliance with the specifications of this Protocol.

11.1.3 Equipment calibration data or logs, certifying that the equipment was calibrated, in compliance with the provisions of this Protocol, prior to conducting the test.

11.1.4 Tabulated data on pressure measurements on the top and bottom surfaces of the instrumented component for each wind speed to which pressure measurements were taken.

11.1.5 Coefficient of pressure calculations for the top and bottom pressure tapping measurements (C_{Pt} and C_{Pb}, respectively) using the tabulated data noted in 11.1.4. Tabulate the results from these calculations.

11.1.6 Coefficient of lift (C_L) calculations, including confirmation that the variation in results is less than 5 percent. If the variation is less than 5 percent, include determination of an average C_L value. (These calculations are only required for 'S' shaped clay or concrete tile systems.)

11.1.7 Adjusted coefficient of moment (C'_{Ma}) calculations and results.

11.1.8 Coefficient of moment (C'_{Ma}) calculations, including confirmation that the variation in results is less than 5 percent. If the variation is less than 5 percent, include determination of the average of the C_{Ma} values. If the variation is greater than 5 percent, the C_{Ma} value at the maximum wind speed shall be utilized to determine the aerodynamic multiplier (l). These calculations are not required for 'S' shaped clay or concrete tile systems.

11.1.9 Aerodynamic multiplier (λ) calculations from Section 10.5 for 'S' shaped clay or concrete tile systems or from Section 10.6 for all other systems.

11.1.10 Photographs of the following:

- the test specimen prior to the test;
- the test specimen after the test; and,
- the instrumented component (showing the pressure tappings and tubes

on the top and bottom surfaces of the component)

11.1.11 The test report shall be signed and sealed by a professional engineer or a registered roof consultant.

NOTE: If the coefficients noted in Section 10 are determined with a computer program, provide confirmation that the equations in the program are in compliance with the provisions of this protocol. If this is the case, the report requirements noted in Sections 11.1.6 through 11.1.9 shall not be required.

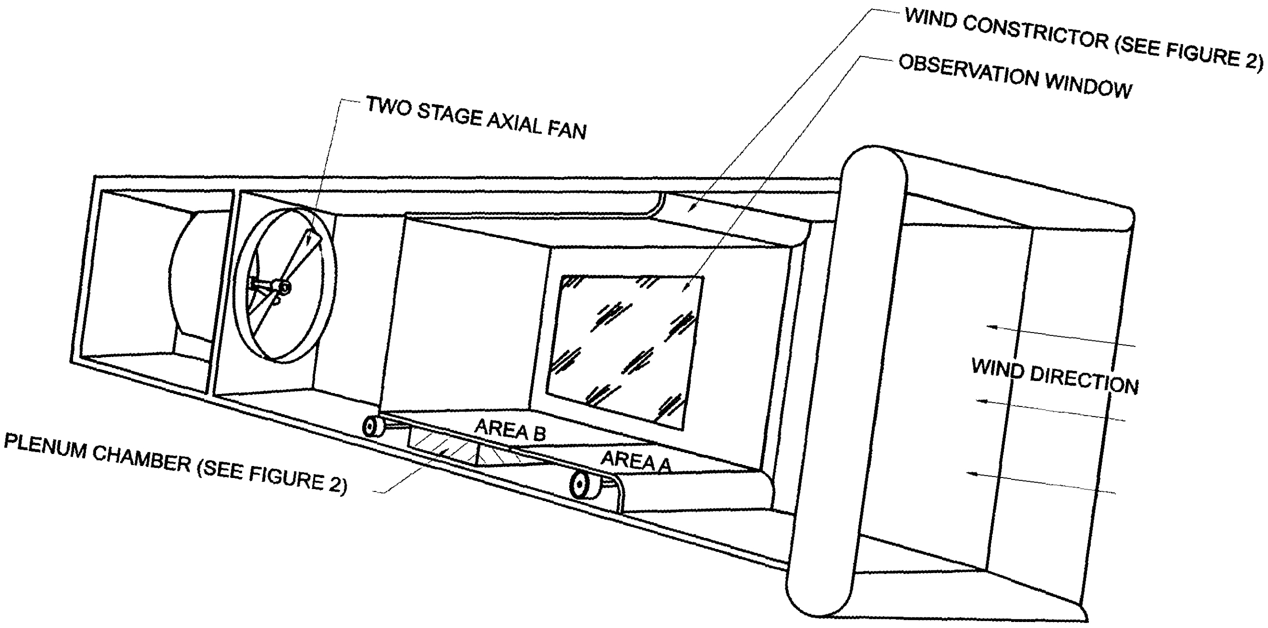


FIGURE 1
WIND TUNNEL TEST APPARATUS

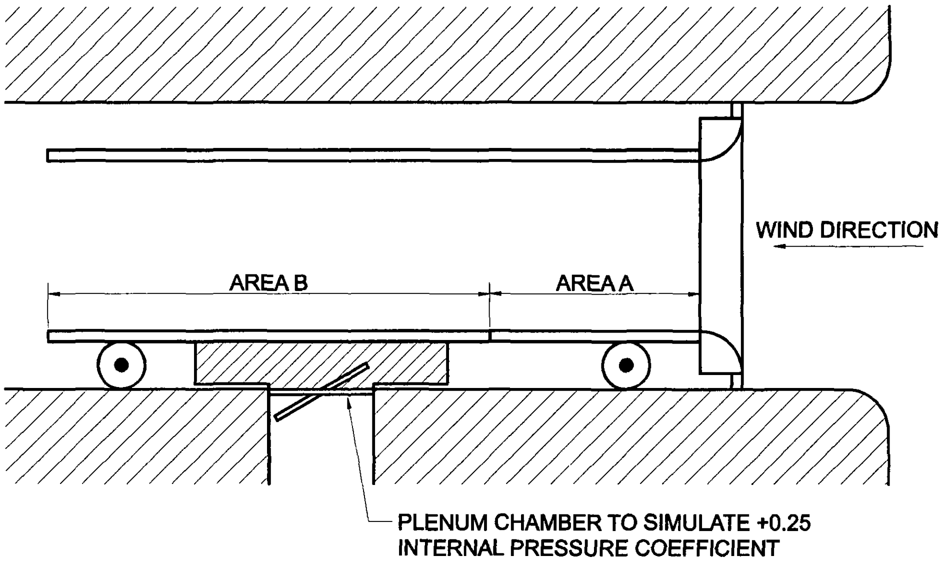

WIND DIRECTION
AREA B
AREA A
PLENUM CHAMBER TO SIMULATE +0.25 INTERNAL PRESSURE COEFFICIENT

FIGURE 2
WIND TUNNEL TEST APPARATUS (SIDE VIEW)

TESTING APPLICATION STANDARD (TAS) No. 110-2000

TESTING REQUIREMENTS FOR PHYSICAL PROPERTIES OF ROOF MEMBRANES, INSULATION, COATINGS, AND OTHER ROOFING COMPONENTS

1. General

1.1 Approved roof assemblies and the Roofing Components therein shall be in compliance with the applicable ASTM Standards, and those outlined in this Testing Application Standards herein. Products not addressed herein shall be tested according to the authority having jurisdiction.

2. Conventional Asphalt Built-up and Modified Bitumen Roof Assemblies

2.1 Conventional built-up and modified bitumen roof assemblies shall be tested in compliance with the requirements set forth in TAS 114.

2.2 Roofing components within asphalt built-up and modified bitumen roof assemblies shall be in compliance with the following requirements, as applicable.

PRODUCT	TEST STANDARD
Membrane or Roll Roofing Products	
Asphalt Cap Sheets	D 228
Asphalt Coated Fiberglass Base Sheet	D 4601
Asphalt Glass Felt for Roofing	D 2178
Asphalt Coated Fiberglass Vented Base	D 4897
Asphalt Coated Organic Base Sheet	D 2626
Asphalt Organic Roll Roofing	D 371
Asphalt Saturated Felt (Spec.)	D 250
Asphalt Saturated Felt	D 226
Roll Roofing, Glass Mat, Granule Surface	D 3909
Roll Roofing, Organic, Smooth Surface	D 224
Roll Roofing, Organic, Granule Surface	D 249
Modified Bitumen Membranes	D 5147 D6162 D6163 D6164
Mechanically Attached Anchor or Base Sheets	TAS 117(B)
Other Components	
Asphalt Used In Roofing	D 312
Asphalt Roof Cement (Asbestos Free)	D 4586

PRODUCT	TEST STANDARD
Membrane or Roll Roofing Products	
Asphalt Lap Cement	D 4022
Cement Wet/Underwater Application	D 3409
Emulsified Asphalt Adhesive	D 3747
Asphalt Primer	D 41
Lap Cement Used in Asphalt Roll Roofing	D 3019
Mineral Aggregate	D 1863
Insulation	See Section 8 herein
Fasteners, Stress Plates, etc.	See Section 13 herein

3. Coal-Tar Pitch Built-up Roof Assemblies:

3.1 Coal-tar pitch built-up roof assemblies shall be tested in compliance with the requirements set forth in TAS 114.

3.2 Roofing components within coal-tar pitch built-up roof assemblies shall be in compliance with the following requirements, as applicable.

PRODUCT	TEST STANDARD
Membrane or Roll Roofing Products	
Coal-Tar Roofing Felts	D 4990
Coal-Tar Saturated Felts	D 227
Mechanically Attached Anchor or Base Sheets	TAS 117(B)
Other Components	
Coal-Tar Pitch	D 450
Coal-Tar Roof Cement	TAS 142
Coal-Tar Primer	D 43
Insulation	See Section 8 of this Protocol
Fasteners, Stress Plates, etc.	See Section 13 of this Protocol

[1] Dynamic pull-over testing of all anchor or base sheets used in Approved roof assemblies shall be in compliance with TAS 117(B).

4. Single-Ply Roof Assemblies:

4.1 Single-ply roof assemblies shall be tested in compliance with the requirements set forth in Testing Application Standard TAS 114.

4.2 Roofing components within single-ply roof assemblies shall be in compliance with the following requirements, as applicable.

5. Liquid Polyethylene Roof Assemblies:

5.1 Liquid applied neoprene and chlorinated polyethylene membrane (CPM) roof assemblies shall be tested in compliance with the requirements set forth in TAS 114.

5.2 Liquid applied neoprene and chlorinated polyethylene membrane (CPM) shall be in compliance with ASTM D 3468.

PRODUCT	TEST STANDARD
Membrane Products	
Thermoplastic Sheet Roofing (Spec.)	D 4434
Vulcanized Rubber Sheet Roofing - EPDM (Spec.)	D 4637
Poly-isobutylene Sheet Roofing - PIB (Spec.)	D 5019
Polyethylene Chlorinated Polyethylene Sheet Roofing – CMS (Spec.)	D 5019
Hypalon Sheet Roofing	D 5019
Thermoplastic Olefin Elastomer Sheet Roofing - TPO	TAS 131
All Single-Ply Membranes	TAS 117(B)
Other Components	
Sealants	TAS 132
Insulation	See Section 7 of this Protocol
Fasteners, Stress Plates, etc.	See Section 12 of this Protocol

[1] Dynamic pull-over testing of single-ply membranes TAS 117(B) is not required for those mechanically attached single-ply roof assemblies tested for uplift pressure resistance in compliance with Appendix 'B' of TAS 114.

6. Spray-Applied Polyurethane Foam Roof Assemblies:

6.1 Spray-applied polyurethane foam roof assemblies shall be tested in compliance with the applicable requirements set forth in TAS 114. As an alternative to uplift pressure resistance tests noted in TAS 114, spray-applied polyurethane foam roof assemblies may be tested for uplift pressure resistance in compliance with UL 1897.

6.1.2 RAS 109 includes requirements regarding field uplift resistance testing in compliance with TAS 124 and small scale adhesion testing in compliance with TAS 109(A). These tests shall be performed based on requirements set forth in RAS 109.

6.2 Spray-applied polyurethane foam shall be in compliance with the following physical property requirement.

Physical Property	Test Standard	Requirement
Water Absorption (@ 73.4°F + 3.6°F for 96 hours @ 2 in. head)	D 2842	max. 0.10 psf (surface area) or max. 1.0% (by volume)
Dimensional Stability (@160°F and 100% relative humidity for 28 days)	D 2126	max. 15% by volume
Water Vapor Permeability (@ 74°F)	C 355	max. 2.5 perm·inch
Compressive Strength (@ yield parallel to rise)	D 1623	min. 40 psi
Tensile Strength	D 1623	min. 60 psi
Shear Strength	C 273	min. 35 psi
Closed Cell Content	D 1940 D 2856	min. 90%
Uplift Resistance	TAS 114 or UL 1897	min. -45 psf

7. Coatings:

7.1 Roof coatings shall be in compliance with the following requirements, as applicable.

Product	Test Standard
Liquid Applied Acrylic Roof Coating Used in Polyurethane Foamed Roofing	ASTM D 6083
White Elastomeric Roof Coating	ASTM D 6083
Coal-Tar (Cutback) Roof Coating	TAS 141
Non-Fibered Roof and Foundation Coating	TAS 140
White Roof Patch	TAS 139
Aluminum Pigmented Emulsified Asphalt Roof Coating	TAS 138
Asphalt Roof Coating (Asbestos Free)	D 4479
Emulsified Bitumen Roof Coatings	D 2939

8. Roofing Insulation:

8.1 Roofing insulation products shall be approved for use with specific roof assembly and shall be listed in such roof assembly Product Approval.

8.2 Roof and sheathing insulation products used in approved roof assemblies shall be in compliance with the following requirements, as applicable.

Physical Property	Test Standard	Requirement
Expanded Polystyrene (EPS)		
Standard Specification	C 578	Type IX
Density	C 303	nom. 1.8 lbs/ft^3
Compressive Strength	D 1621	min. 25 psi
Flexural Strength	C 203	min. 50 psi
Thermal Resistance	C 518	
Water Absorption	C 272	max. 2.0%
Water Vapor Permeance	E 96	max. 2.5 perm
Dimensional Stability	D 2126	max. -2%
Flame Spread	E 84	max. < 75
Extruded Polystyrene (XPS)		
Standard Specification	C 578	Type IV
Density	C 303	nom. 1.6 lbs
Compressive Strength	D 1621	min. 20 psi
Flexural Strength	C 203	min. 50 psi
Thermal Resistance	C 518	
Water Absorption	C 272	max. 0.30%
Water Vapor Permeance	E 96	max. 1.0 perm
Dimensional Stability	D 2126	max. 2%
Flame Spread	E 84	max. < 75
Fiberglass/Mineral Woodfiber		
Standard Specification	C 726	
Compressive Strength	C 165	min. 30 psi
Thermal Resistance	C 518	
Water Absorption	C 209	max. 10%
Water Vapor Permeance	E 96	max. 0.3 perm
Flame Spread	E 84	max. 20
Linear Expansion	C 208 Class C & E	max. 0.5%
Wood Fiberboard		
Standard Specification	C 209	
Water Absorption	C 209	max. 10%
Compressive Strength	C 165	nominal 30 psi
Thermal Resistance	C 518	
Perlite		
Standard Specification	C 728	
Compressive Strength	C 165 Procedure "A"	min. 35 psi
Flexural Strength	C 203	min. 40 psi
Tensile Strength	C 209	575 lb/ft^2
Thermal Resistance	C 518	
Water Absorption	C 209	max. 1.5%
Water Vapor Permeability	C 355	max. 25 perm-inch
Dimensional Stability	D 2126	max. 2%
Flame Spread	E 84	max. < 75

Physical Property	Test Standard	Requirement
Polyisocyanurate		
Density	D 1622	nominal 2 pcf
Compressive Strength	D 1621	min. 18 psi
Thermal Resistance	C 518 PIMA CP 101	report
Water Absorption	C 209	max. 1.0%
Water Vapor Permeance	E 96	max. 1.0 perm
Dimensional Stability (7Days)	D 2116	max. 2%
Flame Spread	E 84	max. < 75
Spread of Flame (with Roof Cover)	E 108	min. Class 'B'

9. Fiber Cement, Discontinuous Roof Assemblies

9.1 Fiber cement, discontinuous roof assemblies shall be installed in compliance with the requirements set forth in the roof assembly Product Approval.

Product	Test	Test Standard
Fiber Cement Roof Assembly	Wind Driven Rain Resistance	TAS 100
Fiber Cement Roofing Products	Physical Properties	TAS 135
Mechanical Attached Fiber Cement Tile or Shake Roof Assemblies (Uplift Based System)	Static Uplift Resistance	TAS 102(A) (See TAS 135 for details)
Mechanically Attached, Clipped Fiber Cement Tile or Shake Roof Assemblies (Uplift Based System)	Static Uplift Resistance	TAS 102(A) (See TAS 135 for details)
Fiber Cement Panel Roof Assemblies	Uplift Pressure Resistance	E 330 (See TAS 135 for details)
Underlayment		
Self-Adhered Underlayments	Physical Properties	TAS 103
Nail-On Underlayments	Physical Properties	TAS 104
Asphalt Based Underlayments	Physical Properties	See Section 2 of this Protocol
Attachment Components		
Nails, Screws, Clips, etc.	Corrosion Resistance	Appendix E of TAS 114

All Underlayments with exposure limitation in excess of 30 days must submit enhanced Accelerated Weathering testing in conjunction with applicable Physical Properties testing. Exposure limitations up to a maximum of 180 days will be established through ASTM D 4798 as outlined in ASTM D 5147 for 1000 hours (cycle A); pass /fail established by physical properties testing of the weathered samples. Physical property testing where specimen size will not fit into the accelerated weathering device may be omitted.

9.2 All fiber cement, discontinuous roof assemblies, and the roofing components therein, shall be tested in compliance with the following requirements, as applicable.

10. Non-Rigid, Discontinuous (Shingle) Roof Assemblies:

10.1 Non-rigid, discontinuous roof assemblies shall be installed in compliance with the requirements set forth in the roof assembly Product Approval.

10.2 All non-rigid, discontinuous roof assemblies, and the roofing components therein, shall be tested in compliance with the following requirements, as applicable.

Product	Test	Test Standard
Non-Rigid, Discontinuous Roof Assembly	Wind Driven Rain Resistance	TAS 100
Non-Rigid, Discontinuous Roof Assembly	Wind Resistance	TAS 107
Non-Rigid, Discontinuous Roof Assembly	Fire Resistance min. Class 'B'	E 108 min. Class 'B'
Granule Surfaced, Glass Felt Asphalt Shingles	Physical Properties	D 3462
Granule Surfaced, Class 'A' Asphalt Shingles Fiberglass Reinforced	Physical Properties	D 3018 TAS 135
Composite Shingles Fiber Cement Shingles	Physical Properties	TAS 135
Metal Shingles	Salt Spray and Accelerated Weathering	B 117 and G 23
Underlayment		
Self-Adhered Underlayments	Physical Properties	TAS 103
Nail-On Underlayments	Physical Properties	TAS 104
Asphalt Based Underlayments	Physical Properties	See Section 2 of this Protocol
Attachment Components		
Nails, Screws, Clips, etc	Corrosion Resistance	Appendix E of TAS 114

All Underlayments with exposure limitation in excess of 30 days must submit enhanced Accelerated Weathering testing in conjunction with applicable Physical Properties testing. Exposure limitations up to a maximum of 180 days will be established through ASTM D 4798 as outlined in ASTM D 5147 for 1000 hours (cycle A); pass/fail established by physical properties testing of the weathered samples. Physical properties testing where specimen size will not fit into the accelerated weathering device may be omitted.

11. Rigid, Discontinuous (Tile) Roof Assemblies:

11.1 Rigid, discontinuous roof assemblies shall be applied in compliance with the requirements set forth in the roof assembly Product Approval.

11.2 All rigid, discontinuous roof assemblies, and the roofing components therein, shall be tested in compliance with the following requirements, as applicable.

Product	Test	Test Standard
Mechanically Attached Rigid, Discontinuous Roof Assembly	Wind Driven Resistance	TAS 100
Mechanically Attached Rigid, Discontinuous Roof Assembly	Static Uplift Resistance	TAS 102
Mechanically Attached Clipped, Rigid, Discontinuous Roof Assembly	Static Uplift Resistance	TAS 102(A)
Mortar or Adhesive Set Tile Roof Assembly	Static Uplift Resistance	TAS 101
Rigid, Discontinuous Roof Assembly	Wind Tunnel Performance	TAS 108
Rigid, Discontinuous Roof Assembly	Air Permeability	TAS 116

1. Wind tunnel testing of rigid, discontinuous roof assemblies is optional and is only applicable to systems having rigid components which meet the size constraints set forth in TAS 108.
2. Air permeability testing of rigid, discontinuous roof assemblies is only applicable to those systems which are to be tested in compliance with TAS 108 and is not required for those systems generally considered to be air permeable. This is a test to confirm the roof assembly would apply to wind tunnel testing.
3. All Underlayments with exposure limitation in excess of 30 days must submit enhanced Accelerated Weathering testing in conjunction with applicable Physical Properties testing. Exposure limitations up to a maximum of 180 days will be established through ASTM D 4798 as outlined in ASTM D 5147 for 1000 hours (cycle A); pass/fail established by physical properties testing of the weathered samples. Physical properties testing where specimen size will not fit into the accelerated weathering device may be omitted.

12. Steel:

12.1 Galvanized steel shall be in compliance with Standard A 525.

13. Mechanical Attachment Components:

13.1 All nails, metal fasteners, batten bars and stress distribution plates shall be tested for corrosion resistance in compliance with Appendix E of TAS 114.

13.1.1 All roofing nails and tin-caps shall be tested for corrosion resistance in compliance with TAS 114 Appendix E, Section 2 (ASTM G 85).

13.1.2 All roof tile nails or fasteners, except those made of copper, monel, aluminum, or stainless steel, shall be tested for corrosion resistance in compliance with TAS 114 Appendix E, Section 2 (ASTM G 85), for salt spray for 1000 hrs.

13.2 Fasteners for attachment of anchor or base sheets, insulation products or single-ply membranes to various substrates shall be tested for withdrawal resistance in compliance with TAS 117(A).

13.3 Metal stress plates, whether separate or integral to a particular fastener, shall be tested in compliance with TAS 117(B) with various anchor or base sheets or single-ply membranes (i.e. the type of product the plate is design to attach) to determine the dynamic pull-through per-

Product	Test	Test Standard
Concrete Roof Tile	Physical Properties	TAS 112
Clay Roof Tile	Physical Properties	C 1167
Fiberglass Reinforced Composite Tile	Physical Properties	TAS 135
Fiber Cement Tile or Shakes	Physical Properties	TAS 135
Slate	Physical Properties	C 406
Underlayment		
Self-Adhered Underlayments	Physical Properties	TAS 103
Nail-On Underlayments	Physical Properties	TAS 104
Asphalt Based Underlayments	Physical Properties	See Section 2 of this Protocol
Attachment Components		
Nails, Screws, Clips, etc.	Corrosion Resistance	Appendix E of TAS 114
Mortar (for use in mortar set tile Roof System Assemblies	Physical Properties	TAS 123
Adhesive (for use as a repair or supplemental attachment component)	Physical Properties	TAS 123(A)

formance of the particular membrane with the particular stress plate.

13.3.1 For single-ply membranes, if the mechanically attached, single-ply roof assembly is tested for dynamic uplift pressure resistance in compliance with Appendix B of TAS 114, then no dynamic pull-through testing is required for the metal stress plate/membrane combination used in the dynamic uplift pressure testing.

13.4 Metal and plastic stress plates, whether separate or integral to a particular fastener, shall be tested in compliance with TAS 117(C) to determine the dynamic pull-off performance of the particular stress plate.

13.4.1 For single-ply membranes, if the mechanically attached, single-ply roof assembly is tested for dynamic uplift pressure resistance in compliance with Appendix B of TAS 114, then no dynamic pull-off testing is required for the metal or plastic stress plate/membrane combination used in the dynamic uplift pressure testing.

14. Attic Ventilation Products:

14.1 All approved attic ventilation products (i.e. soffit vent strips, ridge vents, static vents, louvers, turbines and/or powered vents) shall be sized and installed in compliance with the requirements set forth in the Product Approval.

14.2 Approved attic ventilation products shall be in compliance with the following requirements, as applicable.

Product	Test	Test Standard
Attic Ventilation Products (*soffit vent strips, ridge vents, static vents, louvers, turbines, powered vents, etc.*)	Wind and Wind-Driven Rain Resistance	TAS 100(A)
'Small' Protruding Ridge Ventilation Products (*static vents, louvers, turbines, powered vents, etc.*)	Increased Wind Speed Resistance	TAS 100(A)
'Large' Protruding Ridge Ventilation Products (*turbines, powered vents, etc.*)	Pressure Resistance	TAS 100(B)
Plastic Ridge Vents	Sunlight Resistance	D 1929
Plastic Ridge Vents	Burning Resistance	D 635

15. Metal Panel Roof Assemblies:

15.1 All structural and nonstructural metal panel roof assemblies, and the roofing components therein, shall be tested in compliance with the following requirements, as applicable.

Product	Test	Test Standard
Structural and Non-Structural Metal Panel Roof Assembly	Standard Requirements	TAS 125
Structural and Non-Structural Metal Panel Roof Assembly	Fire Resistance	E 108 (min. Class 'B')
Structural and Non-Structural Metal Panel Continuous Roof Assembly	Accelerated Weathering	G 23 or G 26 (2000 hours)
Structural or Non-Structural Metal Panels	Salt Spray	B 117 (1000 hours)
Insulated Metal Panels	Thermal Value	C 518 (report)

16. Edge Metal and Flashings:

16.1 Edge metal and flashings and their installation shall be in compliance with the requirements set forth in RAS 111.

16.1.1 Edge metal, including drip edge/gravel stop and metal profiles, may be tested for attachment performance in compliance with TAS 111(A) and TAS 111(B), the results from which shall be used to determine adequate attachment to resist wind induced upward and outward forces, as set forth in Chapter 16 of this code.

16.1.2 Coping caps shall be tested for attachment performance in compliance with TAS 111(C), the results from which shall be used to determine adequate attachment to resist wind induced upward and outward forces, as set forth in Chapter 16 *Florida Building Code, Building*.

17. Non-Rigid Tiles/Shakes/Slate/Shingles Products (Plastic):

17.1 Non-Rigid, discontinuous roof assemblies shall be applied in compliance with the requirements set forth in the roof assembly Product Approval.

17.2 All non-rigid, discontinuous roof assemblies, and roofing components therein, shall be tested in compliance with the following requirements, as applicable.

Product	**Test**	**Test Standard**
Non-Rigid, Discontinuous Roof Assembly	Wind Driven Rain Resistance	TAS-100
Plastic Tile/Shake/Slate Systems	Uplift Performance	TAS-125
Plastic Tile/Shake/Slate	Outdoor Exposure Xenon Arc	G 26 (6500 watts) Test Method 1 or G155 (4500 hours)
	Tensile Test	D 638 (+/- 10% allowable difference between exposed and non-exposed samples)
	Flexural Test	C 158 (+/- 10% allowable difference between exposed and non-exposed samples)
Plastic Tile/Shake/Slate	Self Ignition	D 1929 (greater than 650°F)
Plastic Tile/Shake/Slate	Smoke Density Rating	E 84 (rating less than 450) or D2843 (rating less than 75)
Plastic Tile/Shake/Slate	Rate of Burning	D 635 (Class C1 or C2)
Underlayment		
Self Adhered Underlayments	Physical Properties	TAS-103
Nail-On Underlayments	Physical Properties	TAS-104
Asphalt Based Underlayments	Physical Properties	See Section 2 of this Protocol
Attachment Components		
Nails, Screws, Clips, etc.	Corrosion Resistance	Appendix E of TAS 114

All Underlayments with exposure limitation in excess of 30 days must submit enhanced Accelerated Weathering testing in conjuntion with applicable Physical Properties testing. Exposure limitations up to a maximum of 180 days will be established through ASTM D 4798 as outlined in ASTM D 5147 for 1000 hours (cycle A); pass/fail established by physical properties testing of the weathered samples. Physical properties testing where specimen size will not fit into the accelerated weathering device may be omitted.

TESTING APPLICATION STANDARD (TAS) No. 111(A)-95

TEST PROCEDURE FOR ROOF EDGE TERMINATION PERFORMANCE

1. Scope:

1.1 This protocol covers determination of the attachment performance of roof edge terminations.

1.2 The test procedures outlined in this protocol determine whether a roof edge termination, consisting of woodblocking, termination metal and the type of membrane being terminated, performs to resist an oblique load of 100 lbf/ft, as required in RAS 111.

1.3 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a professional engineer or registered roof consultant.

2. Referenced Documents:

2.1 *ASTM Standards:*

E 380 Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.2 *The Florida Building Code, Building.*

2.3 *Application Standards:*
RAS 111 Standard Requirements for Attachment of Perimeter Woodblocking and Metal Flashings

2.4 *Single Ply Roofing Institute:*
SPRI Edge Design Guide, March 1994

2.5 *Roof Consultants Institute:*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions—For definitions of terms used in this specification, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building*; and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 The method with which the edge of a roofing membrane is terminated (edge metal and woodblocking) is the last anchor point to hold the membrane in place should the membrane happen to separate from the roof deck during high winds. When this occurs, the membrane termination construction incurs a significant load.

4.2 The test procedure outlined herein provides a means for determining whether a particular membrane termination detail performs to resist an oblique load of 100 lbf/ft.

5. Apparatus:

5.1 The test apparatus shall consist of a tensile tester fitted with a suitable holding device for the membrane termination being tested. The load recording device attached to the tensile tester shall be capable of recording loads up to 300 lbf. (See Figures 1 and 2, herein.)

6. Test Limitations and Precautions:

6.1 This protocol may involve hazardous materials, operations and equipment. This protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Test Specimen:

7.1 The test specimen shall consist of a 12 inch wide 'mock-up' of the termination system as it would be installed in an actual field application. Not less than five test specimens shall be constructed and tested.

8. Procedure

8.1 Mount the 12 inch wide test specimen to the base or holding device of the tensile tester such that the membrane is pulled at a 45-degree angle to the attachment substrate. This angle is chosen to simulate a 'billowing' membrane.

8.2 Photograph the test specimen prior to testing.

8.2 Connect the tensile tester jaws to two bars which clamp the membrane edge creating even load distribution across the 12 inch specimen width.

8.3 Apply uniform load at a constant rate to the membrane until failure, as noted below, occurs.

8.3.1 Failure is defined as any event which allows the membrane to come free of the edge termination or the termination to come free from the substrate.

8.4 Photograph the test specimen subsequent to failure.

8.5 Record the failure load for each of five test specimens and calculated an average failure load.

9. Interpretation of Results:

9.1 The membrane termination system shall record an average failure load not less than 100 lbf.

10. Report:

10.1 The final report shall include the following:

10.1.1 A complete description of the membrane termination system, including membrane type and attachment, edge metal type, material, thickness and attachment, and the attachment substrate (i.e., woodblocking, etc.).

10.1.2 Recorded failure loads for each of five test specimens and an average failure load.

10.1.3 Photographs of the test specimens prior and subsequent to failure.

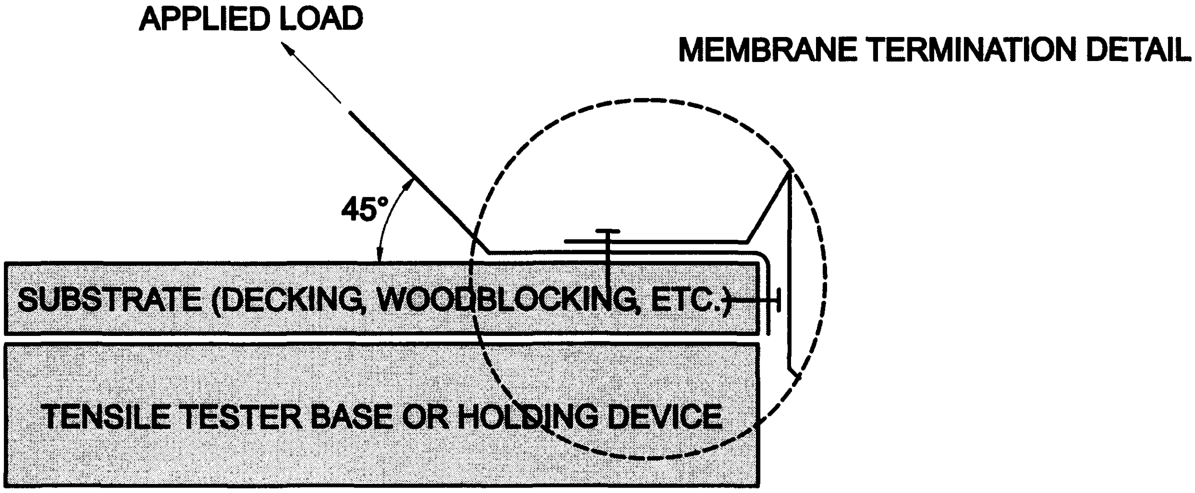

APPLIED LOAD
MEMBRANE TERMINATION DETAIL
45°
SUBSTRATE (DECKING, WOODBLOCKING, ETC.)
TENSILE TESTER BASE OR HOLDING DEVICE

FIGURE 1
MEMBRANE TERMINATION PERFORMANCE TEST CONFIGURATION OPTION

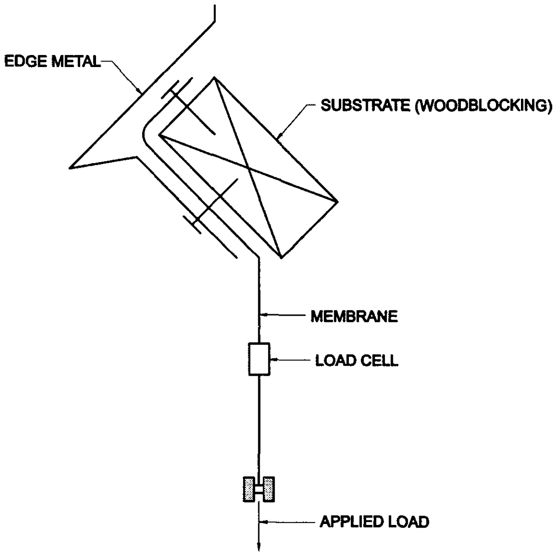


FIGURE 2
MEMBRANE TERMINATION PERFORMANCE TEST CONFIGURATION OPTION

TESTING APPLICATION STANDARD (TAS) No. 111(B)-95

TEST PROCEDURE FOR EDGE METAL PULL-OFF PERFORMANCE

1. Scope

1.1 This protocol covers determination of the pull-off resistance performance of various edge metal configurations when subjected to uniform loading.

1.2 The test procedures outlined in this protocol determine the resistance to uniform loading of an edge metal configuration, such as drip edge, gravel stop or metal profile, as required in RAS 111. Resistance to uniform loading is determined for the horizontal (deck) flange (upward loading) and the vertical (face) flange (outward loading).

1.3 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a professional engineer or registered roof consultant.

2. Referenced Documents

2.1 *ASTM Standards:*

E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.2 *The Florida Building Code, Building.*

2.3 *Application Standards:*

RAS 111	Standard Requirements for Attachment of Perimeter Woodblocking and Metal Flashings

2.4 *Single Ply Roofing Institute:*
SPRI Edge Design Guide, March 1994

2.5 *Roof Consultants Institute:*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions—For definitions of terms used in this specification, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building*; and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 The test procedure outlined herein provides a means for determining the maximum upward and outward pressures which a perimeter edge metal system can resist without failure.

4.2 Results from this testing are used to determine whether a proposed perimeter edge metal system will provide sufficient resistance to upward and outward pressures to meet or exceed corresponding design pressures for perimeter and corner areas of a particular building, determined in compliance with Section 6 of RAS 111.

5. Apparatus:

5.1 Load application device:

5.1.1 The load application device shall consist of a tensile tester, or other device capable of providing uniform load, fitted with a load cell capable of recording loads up to 10,000 lbf.

5.1.2 The load application device shall be fitted with an 11 foot long clamp or a series of ten 2 inch wide clamps capable of grasping a series of ten 12 ga. annular ring shank nails which form part of the load transfer device.

5.2 Load transfer device:

5.2.1 The load transfer device shall consist of a 1 inch wide x 11 foot long x $^1/_8$ inch thick steel bar with $^1/_8$ inch diameter predrilled holes spaced 12 inches o.c. with the two end holes located $^1/_2$ inch from each end of the bar.

5.2.2 The 11 feet long steel bar shall be mounted to the underside of the flange or load resisting component of the edge metal using 12 ga. x $1^1/_2$ inch long annular ring shank nails.

5.3 A schematic of the test apparatus is provided in Figure 1, herein.

5.4 The description of the test apparatus is general in nature and may be altered for ease of testing, provided the intent of the test is maintained.

6. Test Limitations and Precautions:

6.1 This protocol may involve hazardous materials, operations and equipment. This protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Test Specimen:

7.1 The test specimen shall consist of a 10 foot long 'mock-up' of the edge metal as it would be installed in an actual field application. Not less than five test specimens shall be constructed and tested for each directional load (i.e., upward for deck flange and outward for vertical flange/face).

7.2 Prior to installation of the edge metal test specimen to its substrate, install the 11 foot long steel bar (load transfer device) through the back of the flange or load resisting component which is to be tested (i.e. deck flange, face flange or face cleat or hook strip) using 12 ga. x $1^1/_2$ inch long annular ring shank nails such that the points of the nails are directed outwardly normal from the load resisting component. (See Figure 1, hereinch)

8. Procedure:

8.1 Photograph the test specimen prior to testing.

8.2 Position the test specimen, fitted with the load transfer device, in front of the load application device (tensile tester) and attach the 11 foot long clamp or series of ten clamps to the ends of the load transfer nails such that the clamp(s) do not interfere with the movement of the edge metal whatsoever and load generated from the load application device is normal to the surface of the edge metal flange or load resisting component being tested.

8.3 Apply an initial load of 300 lbf to the load transfer device and hold the applied load for a period of one minute. At the end of one minute, reduce the load to zero and allow the test specimen to sit at zero-load for a period of two minutes. Thereafter, increase the applied load to 350 lbf and hold the applied load for a period of one minute. At end of one minute, reduce the load to zero-load and allow the test specimen to sit at zero-load for a period of two minutes. Continue this procedure in load increments of 50 lbf until failure, as defined below, occurs.

8.3.1 Failure is defined as any occurrence of the following:

- loss of securement;
- permanent deformation; or,
- component failure that will not allow the edge metal to perform as designed.

8.4 Photograph the test specimen subsequent to failure.

8.5 Record the failure load and the time at which failure occurred for each of five test specimens and calculated an average failure load.

9. Interpretation of Results:

9.1 Convert the average failure load to pressure using the following equation:

where:

P = maximum pressure (psf);
F = average failure load (lbf); and,
A = area of flange or load resistance component

9.2 The maximum pressure (outward or upward) shall meet or exceed corresponding design pressures for perimeter and corner areas of a particular building, determined in compliance with Section 6 of RAS 111.

10. Report:

10.1 The final report shall include the following:

10.1.1 A complete description of the edge metal system, including edge metal type, material, thickness and attachment, cleat or hook strip type, material, thickness, dimensions and attachment (if any), and the attachment substrate (i.e. woodblocking, etc.)

10.1.2 Recorded failure loads for each of five test specimens, an average failure load and a maximum pressure of the edge metal system.

10.1.3 Photographs of the test specimens prior and subsequent to failure.

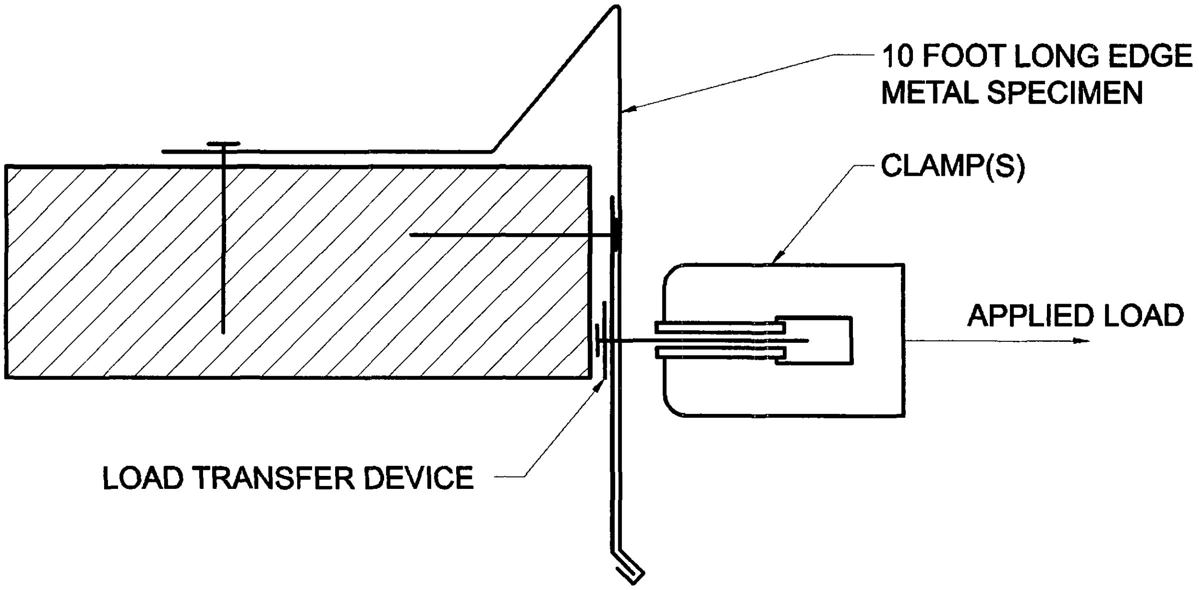


FIGURE 1
VIEW OF OUTWARD LOADING OF EDGE METAL VERTICAL FLANGE
(UPWARD LOADING OF HORIZONTAL FLANGE ALSO REQUIRED)

TESTING APPLICATION STANDARD (TAS) No. 111(C)-95

TEST PROCEDURE FOR COPING CAP PULL-OFF PERFORMANCE

1. Scope:

1.1 This protocol covers determination of the pull-off resistance performance of various coping cap configurations when subjected to uniform loading.

1.2 The test procedures outlined in this protocol determine the resistance to uniform loading of a coping cap configuration, as required in RAS 111. Resistance to uniform loading is determined for the top face (upward loading) and both vertical (face) flanges (outward loading) of the coping cap.

1.3 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a professional engineer or registered roof consultant.

2. Referenced Documents:

2.1 *ASTM Standards:*

E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.2 *The Florida Building Code, Building.*

2.3 *Application Standards:*

RAS 111	Standard Requirements for Attachment of Perimeter Woodblocking and Metal Flashings

2.4 *Single Ply Roofing Institute:*
SPRI Edge Design Guide, March 1994

2.5 *Roof Consultants Institute:*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions—For definitions of terms used in this specification, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building*; and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 The test procedure outlined herein provides a means for determining the maximum upward and outward pressures which a coping cap and its attachment can resist without failure.

4.2 Results from this testing are used to determine whether a proposed coping cap and corresponding attachment method will provide sufficient resistance to upward and outward pressures to meet or exceed corresponding design pressures for perimeter and corner areas of a particular building, determined in compliance with Section 6 of RAS 111.

5. Apparatus:

5.1 Load application device

5.1.1 The load application device shall consist of a tensile tester, or other device capable of providing uniform load, fitted with a load cell capable of recording loads up to 10,000 lbf.

5.1.2 The load application device shall be fitted with an 11 foot long clamp or a series of ten 2 inch wide clamps capable of grasping a series of ten 12 ga. annular ring shank nails which form part of the load transfer device.

5.2 Load transfer device

5.2.1 The load transfer device shall consist of a 1 inch wide x 11 foot long by $^1/_8$ inch thick steel bar with $^1/_8$ inch diameter predrilled holes spaced 12 inches o.c. with the two end holes located $^1/_2$ inch from each end of the bar.

5.2.2 The 11 foot long steel bar shall be mounted to the underside of the flange or load resisting component of the coping cap using 12 ga. by $1^1/_2$ inch long annular ring shank nails.

5.3 A schematic of the test apparatus is provided in Figures 1 and 2, herein.

5.4 The description of the test apparatus is general in nature and may be altered for ease of testing, provided the intent of the test is maintained.

6. Test Limitations and Precautions:

6.1 This protocol may involve hazardous materials, operations and equipment. This protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Test Specimen:

7.1 The test specimen shall consist of a 10 foot long 'mock-up' of the coping cap as it would be installed in an actual field application. Not less than five test specimens shall be constructed and tested for each directional load (i.e.,upward load resistance from the top and outward load resistance from each vertical flange).

7.2 Prior to installation of the coping cap test specimen to its substrate, install the 11-foot long steel bar (load transfer device) through the back of the flange or load resisting component which is to be tested (i.e. top, inner or outer vertical flange or cleat/hook strip) using 12 ga. by $1^1/_2$ inch long annular ring shank nails such that the points of the nails are directed outwardly normal from the load resisting component. (See Figures 1 and 2, herein.)

8. Procedure:

8.1 Photograph the test specimen prior to testing.

8.2 Position the test specimen, fitted with the load transfer device, in front of the load application device (tensile tester) and attach the 11-foot long clamp or series of ten clamps to the ends of the load transfer nails such that the clamp(s) do not interfere with the movement of the coping cap whatsoever and load generated from the load application device is normal to the surface of the coping cap flange or load resisting component being tested.

8.3 Apply an initial load of 300 lbf to the load transfer device and hold the applied load for a period of one minute. At the end of one minute, reduce the load to zero and allow the test specimen to sit at zero-load for a period of two minutes. Thereafter, increase the applied load to 350 lbf and hold the applied load for a period of one minute. At end of one minute, reduce the load to zero-load and allow the test specimen to sit at zero-load for a period of two minutes. Continue this procedure in load increments of 50 lbf until failure, as defined below, occurs.

8.3.1 Failure is defined as any occurrence of the following:

- loss of securement;
- permanent deformation; or,
- component failure that will not allow the coping cap to perform as designed.

8.4 Photograph the test specimen subsequent to failure.

8.5 Record the failure load and the time at which failure occurred for each of five test specimens and calculated an average failure load.

9. Interpretation of Results:

9.1 Convert the average failure load to pressure using the following equation:

$$P = \frac{F}{A}$$

where:

P = maximum pressure (psf);

F = average failure load (lbf); and,

A = area of flange or load resistance component

9.2 The maximum pressure (outward or upward) shall meet or exceed corresponding design pressures for perimeter and corner areas of a particular building, determined in compliance with Section 6 of RAS 111.

10. Report:

10.1 The final report shall include the following:

10.1.1 A complete description of the coping cap system, including coping cap type, material, thickness and attachment, cleat or hook strip type, material, thickness, dimensions and attachment (if any), and the attachment substrate (i.e. woodblocking, etc.).

10.1.2 Recorded failure loads for each of five test specimens, an average failure load and a maximum pressure of the coping cap system.

10.1.3 Photographs of the test specimens prior and subsequent to failure.

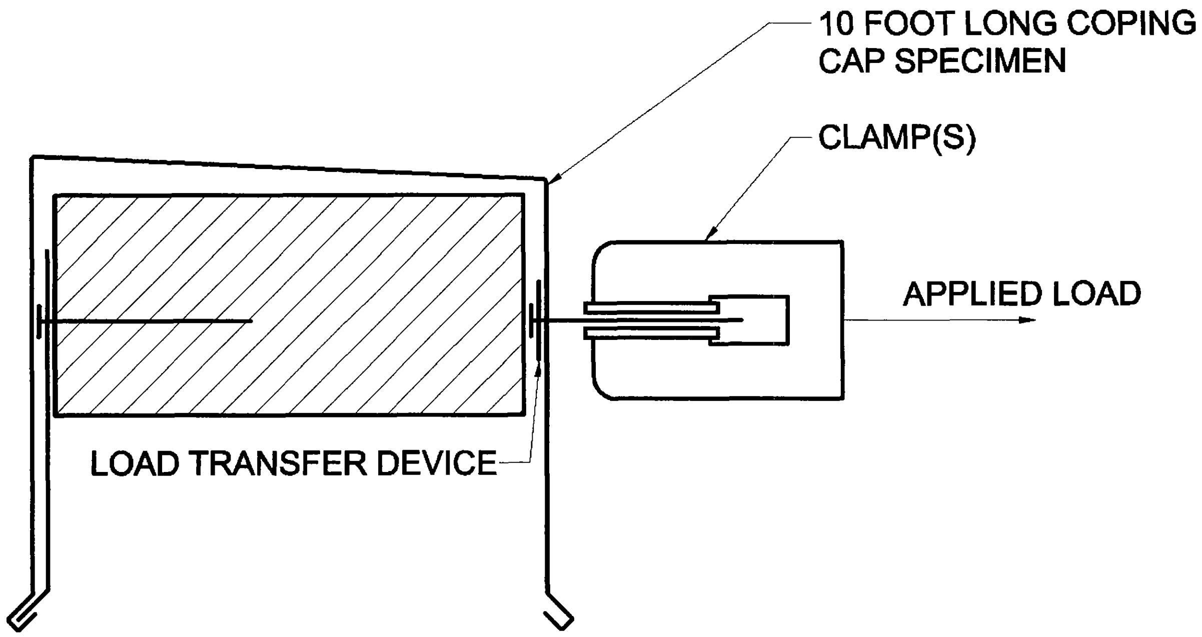


FIGURE 1
VIEW OF OUTWARD LOADING OF COPING CAP VERTICAL FLANGE
(OUTWARD LOADING OF OTHER VERTICAL FLANGE ALSO REQUIRED)

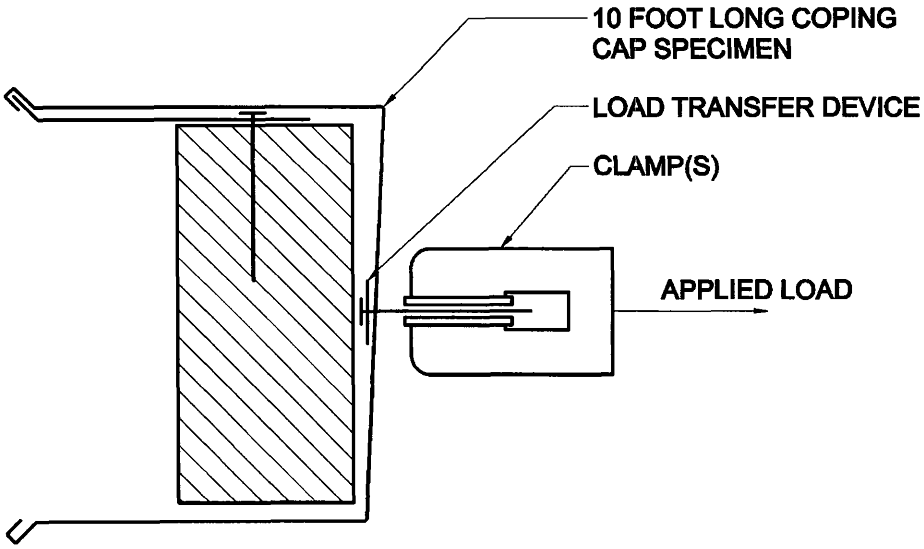


FIGURE 2
VIEW OF OUTWARD LOADING OF COPING CAP VERTICAL FLANGE
(UPWARD LOAD RESISTANCE)

TESTING APPLICATION STANDARD (TAS) No. 112-95

STANDARD REQUIREMENTS FOR CONCRETE ROOF TILES

1. Scope:

1.1 This Protocol covers concrete roof tiles manufactured from Portland cement, water, and mineral aggregates, with or without the inclusion of other materials, see Section 5.3.

Note 1: Concrete roof tiles covered by this specification are made from lightweight or normal weight aggregates or both.

Note 2: When particular features are desired, such as color, surface texture for appearance, or other special features, such properties should be specified by the purchaser. However, the local sellers should be consulted as to the availability of concrete roof tile having a desired feature.

2. Referenced Documents:

2.1 *ASTM Standards:*

C 33	Standard Specification for Concrete Aggregates
C 67	Standard Methods of Testing Brick and Clay Tile
C 150	Standard Specification for Portland Cement
C 260	Standard Specification for Air-Entraining Admixtures for Concrete
C 331	Standard Specification for Lightweight Aggregates for Masonry Units
C 494	Standard Specification for Chemical Admixtures for Concrete
C 595	Standard Specifications for Blended Hydraulic Cements
C 618	Standard Specification for Fly Ash and Raw of Calcined Natural Pozzolan for use as a Mineral Admixture in Portland Cement Concrete
C 979	Standard Specification for Pigments for Integrally Colored Concrete
E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

3. Terminology & Units:

3.1 Definitions—For definitions of terms used in this protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building*; and/or the RCI Glossary of Terms. Definitions of the *Florida Building Code, Building* shall take precedence.

3.2 Definitions—The following terms are used in connection with concrete roof tiles:

Batten lugs:	Protrusions on the underside of the tiles designed to engage over the upper edge of tiling battens.
Flat profile tile:	Flat profile shaped tiles are defined as those tiles having a rise to width ratio equal to 0.00.
Headlap:	The dimension by which the overlap of the nose end of the tiles covers the head end of the tow of tiles immediately under it.
High profile tile:	High profile shaped tiles are defined as those tiles having a rise to width ratio greater than 0.20.
Interlocking tile:	Those tiles with a system of ribs or grooves enabling the lateral joining of adjacent tiles in the same horizontal row, with the overlapping covering the underlapping.

Length:	The maximum overall dimension of the tiles as measured parallel to the interlock.
Low profile tile:	Low profile tiles are defined as those tiles having a rise to width ratio less than or equal to 0.20.
Nail hole:	A small opening passing partially or totally through the tiles to allow the penetration of a nail or screw for the purpose of fastening the tiles to a support.
Noninterlocking tile:	Those tiles without restrictive ribs, grooves or channels at the underlap and overlap.
Nose lugs:	A projecting on the underside of the nose of each tile, contoured to fit into the main water courses of the tiles immediately below, inhibiting the entry of wind driven rainch
Profile:	The contour of the top surface of the tiles when viewed from the nose end.
Side lap:	The width of the section of tiles containing the underlap.
Thickness:	Any vertical measurement of the cross section of the tiles excluding the lapping area, nose lugs, and weather checks.
Width:	The maximum overall dimension of the tiles as measured perpendicular to the length or water channel.
Rise:	The vertical distance from the underside of the batten lug to the highest point of the surface profile.
Water course:	The valley portions of profiled tiles along which water drains.

3.3 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Classifications:

4.1 Concrete roof tiles manufactured in accordance with this specification are of the following types.

4.1.1 *Type 1* Interlocking tiles:
- *Type 1a* High profile shaped tiles
- *Type 1b* Low profile shaped tiles

4.1.2 *Type 2* Noninterlocking tiles:
- *Type 2a* High profile shaped tiles
- *Type 2b* Low profile shaped tiles

4.1.3 *Type 3* Other tile:
- *Type 3a* Flat tile
- *Type 3b* Accessory tiles—shall include those tiles such as ridge, rake, hip, valley and all other tiles used in conjunction with those tiles listed in 4.1 above.

5. Material and Manufacture:

5.1 Cementitious materials—materials shall conform to the following applicable ASTM Test Standards:

C 150	Portland cements
C 595	Blended hydraulic cements
C 618	Fly ash and raw or calcined natural pozzolan for use as a mineral admixture in portland cement concrete.

5.2 Aggregates shall conform to the following applicable ASTM Test Standards, except that grading requirements do not apply:

5.2.1 Normal weight—C 33 concrete aggregates

5.2.2 Light weight—C 331 lightweight aggregates for concrete.

5.3 Other constituents—such as chemical and mineral admixtures established as suitable for use in concrete shall conform to

ASTM Test Standards where applicable, or shall be shown by tests or experience not to be detrimental to the durability of concrete.

6. Standard Methods of Sampling Concrete Tile:

6.1 Tile sampling shall be appropriate for one of the following three purposes:

6.1.1 Resolution of quality disputes

6.1.2 Third-party certification

6.1.3 Specific order verification

6.2 Tile sampling for the purpose listed in 6.1 shall be taken according to Table 3. In the event the first fails, a second set of samples shall be taken and tested in accordance with the criteria listed in Table 3.

6.3 Sampling procedure:

6.3.1 Buyer and Seller shall agree on the method of sampling prior to shipment. Whenever possible, the sampling method shall be such that all tiles in the consignment have equal chance of being selected on each trial. Select the required number of tiles at random throughout the consignment.

7. Standard Method of Testing Concrete Roof Tiles:

7.1 The following tests are required on concrete roof tiles

1. *Dimensional*
2. *Freeze Thaw*
3. *Transverse Strength*
4. *Permeability*
5. *Water Absorption*

7.2 Testing for dimensional tolerances:

7.2.1 Dimensions—The total variation in dimensions of tiles, when measured in accordance with test method C 67, shall not be more than ± 5 percent from the nominal dimensions specified by the supplier.

7.2.2 Weight—The total variation in weight of tiles, when measured in accordance with test method C 67, shall not be more than ± 10 percent from the nominal weight specified by the supplier.

7.3 Test of freeze thaw: **(Section 7.3 shall not be required for the purposes of *Florida Building Code, Building* requirements).**

7.3.1 Tiles shall be subjected to 50 cycles of the freezing and thawing test Method ASTM C 67, as modified in 7.2.2.

7.3.1.1 A lot shall be rated as passing provided that a sample, from the same design, and same materials had passed the test within the previous 12 months.

7.3.2 Modify method ASTM C 67 Section 8.2 as follows: The test specimens shall consist of five whole tiles. The freezing trays and containers shall be of sufficient size and depth to allow the tiles to be completely submerged in water when placed horizontally.

Note: A large capacity freezer may be necessary to accomplish freezing in the manner specified in Test Methods C 67 for trays containing more than one tile. Custom trays may be necessary to enclose the tile(s) and minimize the volume of water required to completely submerge the tile(s).

7.3.2.1 The following alternate procedure may be used to perform the freeze-thaw test in a minimum time.

The test specimens shall consist of five whole tiles. The tiles shall be totally immersed in water at a temperature of 75 ± 10° F (24 ± 6° C) for 24 hours. The tiles shall then be individually sealed in a plastic bag (10 mil (0.25 mm) polyethylene has proved suitable) or between preformed plastic trays with at least 500 cc of water or a sufficient amount that will provide a layer of water between $^1/_{16}$ inch and $^1/_8$ inch (1- to 3-mm) thick surrounding the tile. When using the plastic bags, they should be evacuated to remove the air and then heat sealed to enclose the tile and the water. When using molded trays they should be clamped or otherwise sealed to encapsulate the tile and the water. At least one of the tiles in the sample under test shall be drilled at the mid-point of the top surface to a depth of the mid-plane of the tiles with a hole of $^1/_{16}$ inch (1 mm) with rapid setting epoxy type cement, such that the bead is at the mid-plane of the tile. The sealed tiles may be stacked in a freezer chamber provided that (a) the sample containing the thermocouple is at the center of the stack; and, (b) that at least $^1/_2$ inch (12 mm) space is provided between the tiles.

The stack of tiles shall be placed in the freezer and the temperature lowered until the thermocouple reads 1 ± 5°F (-18 ± 2°C). The tiles shall be maintained at this temperature for at least 30 minutes. The stack shall then be removed from the freezer and placed in the ambient environment (75 ± 5°F (24 ± 6°C) until the thermocouple reads 40 ± 5°F (4 ± 2°C). The tiles shall be returned to the freezing chamber and the cycle repeated. The use of a fan for increasing the flow of ambient air throughout the stack of tiles may be allowed.

Note: The time to complete a cycle of freezing and thawing by this procedure will depend on the capabilities of the freezing chamber. It is the intent of this procedure to assure that the tiles remain in contact with a thin layer of water (or ice) during the test, and to assure that the water within the body of the tiles has been frozen and subsequently has thawed in the process of performing each cycle.

7.4 Transverse strength:

7.4.1 Apparatus: The transverse breaking strength of tiles shall be determined as described in the flexural test in Test Methods C 67 except as modified in 7.4.2 to 7.4.10.

7.4.2 Five tiles shall be tested after conditioned as listed in Section 7.4.11.

7.4.3 The span chosen for the test shall be 12 inches (30.5 cm) ± 5 percent or $^2/_3$ the length of the tile, whichever is greater. The span is measured between the centers of the lower support member. (See Figure 1, attached)

7.4.4 The tile shall be tested in a three-point bending mode in a horizontal plane with the bottom surface of the tile resting on two lower support members and with the load being applied to the upper (exposed) surface of the tile by a third member moving in a direction perpendicular to the plane of the tile and at mid-span (that is, equidistant from each of the lower support members).

7.4.5 The two support members and the loading member shall be of metal or hardwood with 1 inch (25 mm) ± 5 percent wide faces. The faces shall be shaped (see note) to closely conform to the profile of the surface of the tile upon which they bear during the test (the profile may therefore be different for each member depending on the profile and cross-sectional shape of the tile). The total height of the members shall not be more than 1 inch (25 mm) greater than the rise of the profile and, if hardwood, they should be backed up with steel bearing plates at least $^1/_2$ inch (13 mm) thick. A rubber shim strip $^3/_{16}$ inch (4.8 mm) ± 10 percent thick of hardness no greater than shore durometer 30 (A scale), and 1 inch (25 mm) ± 5 percent wide, shall be placed between the faces of the support and loading members and the surface of the tile. A schematic of the assembly for testing a typical "S" tile is shown in Figure 1.

Notes:

1. The intent of the defined loading system is: 1) to apply the bending force with a loading member that pushes against as much of the profiled surface of the tile as practical; 2) to support the tile on members that support as much of the profiled surface of the tile as is practical; and, 3) to ensure that the contact area of both the loading and support members be equally distributed on either side of the length centerline on the tile to avoid non-symmetrical loading.
2. For tile with complex profiles and cross-sections but with flat bearing surfaces which are at least 50 percent of the width of the tile which are also equally distributed on either side of the length centerline, flat support and loading members may be used to perform this test provided that they otherwise comply with the requirements of Sections 7.4.5, 7.4.6, 7.4.7. When sufficient flat bearing surfaces do not exist, wood blocks of appropriate thickness and profile and 1 inch (25 mm) wide, may be used to provide a surface that will permit load application using a flat loading member which otherwise meets the requirements of 7.4.5, 7.4.6 and 7.4.7, and causes the load to be applied to at least 50 percent of the width of the tile and equally distributed on either side of the length centerline of the tile.
3. Each wood block used to provide sufficient flat surface to allow loading and supporting with the flat bearing members shall have a length of at least 25 percent of the width of the tile. Such blocks shall be spaced no farther apart than 25 percent of the width of the tile to avoid concentrated loading. Loading support members shall be parallel to each other and be placed in the same alignment across the width of the tile, when viewed from the end of the tile, to avoid torsional loading.

7.4.6 The length of the support and loading members shall be no greater than the width of the tile.

7.4.7 Both of the support members and the loading member shall be free to rotate in the longitudinal and transverse directions of the test specimen and be adjusted so that they will exert no force in these directions. This may be spherically seated steel balls with appropriate supporting springs.

7.4.8 The tile shall be loaded uniformly and continuously, without shock, at a rate not to exceed 1000 lbf (4550 N)/min until fracture.

7.4.9 Record the load in pounds (kilograms) at the fracture of the five tiles and report the average of the five tests and the minimum individual result.

7.4.10 For tile with a width other than 14 inch (35.6 cm) the minimum values in Table 1 are to be adjusted proportionally to the change in width according to the following:

$$\frac{\text{width (inches)}}{14}$$

7.4.11 Conditioning procedure:

Prior to being tested for transverse breaking strength, the tiles shall be conditioned in one of the two following methods agreed on between the supplier and specifier. a) Dry Testing: Oven dry all tiles at 160°F ± 5°F (71°C ± 3°C) for 24 hours. Then allow to cool to room temperature prior to testing. b) Wet Testing: Submerge the tiles for 24 hours in water at a temperature of 75 ± 10°F (24 ± 6°C).

7.5 Permeability:

7.5.1 Apparatus: Provide a walled frame and stand, as shown in Figure 2, designed to closely surround the perimeter of the tile and provide for the horizontal support of the tile with the exposed surface uppermost, and for sealing around the perimeter. Any support flange or sealant material shall not protrude more than $^1/_2$ inch (12 mm) onto the surface of either side of the tile. The height of the stand shall be sufficient to allow observation of the underside of the tile. The height of the perimeter frame wall should be at least 3 inches (75 mm) greater than the height of the tile profile to be tested.

7.5.2 Procedure: Seal the entire perimeter of the tile in the frame with suitable compound such as putty, mastic, or silicone sealant that will provide a water tight seal. Nail holes shall be similarly sealed. Sealant shall not protrude more than $^1/_2$ inch (12 mm) onto the surface of either side of the tile. Place the frame and stand assembly on a nonabsorbent surface and adjust the stand so the tile is horizontal. Add water at 75 ± 10°F (24 ± 6°C) to a depth of 2 ± $^1/_4$ inch (51 ± 6 mm) measured from the highest point of the upper surface of the tile. Maintain the depth of water for the 24 hour duration of the test and periodically observe the underside of the tile and the surface beneath the stand for signs of water droplets.

7.5.3 Acceptance criteria: The tile shall have passed the test if, after 24 hours, no water droplets have fallen from the underside of the tile. If water droplets have fallen, the tile has failed the permeability test.

7.6 Method for determining water absorption:

7.6.1 Apparatus: The procedures and apparatus shall be in compliance with Section 6 of ASTM Test Standard C 140.

7.6.2 Procedure: Immerse the tile specimen in water at room temperature at 60 to 80°F (15.6 to 26.7°C) for 24 hours. Weigh the specimens while suspended by a metal wire and completely submerge in water. Remove the specimens from the water and allow to drain for 1 minute by placing them on $^3/_8$ inch (9.5 mm) wire mesh. Remove any visible surface water with a damp cloth and weigh to the nearest gram. Subsequent to saturation, dry all specimens in a ventilated oven at 212 to 239°F (100 to 115°C) for a minimum of 24 hours and continue until two successive weight measurements, at intervals of 2 hours, show a weight decrease less than or equal to 0.2

TABLE 1
TRANSVERSE BREAKING STRENGTH, MINIMUM LBF (N)

Tile Profile	Dry Tile		Wet Tile	
	Average of Five Tiles	Individual Tile	Average of Five Tiles	Individual Tile
High Profile	400 (1780)	350 (1557)	300 (1334)	260 (1157)
Low Profile	300 (1335)	260 (1157)	225 (1001)	200 (890)
Flat Profile	250 (1122)	215 (956)	190 (845)	160 (712)

TABLE 2
TILE RATINGS AND MAXIMUM WATER ABSORPTION

Weight Classification	W = Oven Dry Weights of Tile (lb/ft^3)	Max. Water Absorption lb/ft^3-(kg/m^3)
Class I	$W \leq 105$	18 (288)
Class II	$105 < W < 126$	15 (240)
Class III	$W \geq 126$	13 (208)

TABLE 3
NUMBER OF TILES TO BE RE-TESTED

Test	Quality Dispute	Third Party	0 to 250,000	Over 250,000
Freeze Thaw	5	5	*	*
Dimensional	5	5	5	5
Transverse	3	5	3	5
Permeability	3	3	3	5
Water Absorption	3	3	3	5

[1] Freeze Thaw Testing is only required for regions subject to freeze thaw.
[2] Annual test data available.

TABLE 4
RETEST CRITERIA (FAILURE RATE REQUIRED)

Number of Tiles	Number of Samples	Lot of Accepted	Lot Rejected
Less than 50	3	0	1
151-3,200	13	1	2
3,201-35,000	20	2	3
35,001-500,000	32	3	4
Over 500,000	50	5	5

Example: If 250,000 tiles were in a lot, then 32 samples would be taken for the retest of that specific test failed. If 3 of the 32 samples failed, the lot would be rated as passing; however, if 4 of 32 samples failed, the lot would have failed the specific test.

percent of the previously determined weight of the specimen.

Water absorption shall be calculated using the following formula:

$$A = \left[\frac{(E - C)}{E - F} \right] \times 62.4$$

where,

A = absorption (lb/ft^3);

E = Mass of wet unit, (lb.);

C = Mass of dry unit, (lb.); and

F = Suspended immersed weight of unit, (lb.)

Tile utilized in the high-velocity hurricane zone jurisdiction shall be rated and shall meet the absorption requirements noted in Table 2, below.

8. Texture and Color:

8.1 The texture and color of tiles should be specified by the purchaser and mutually agreed upon between purchase and supplier with reference to a sample of the type specified representing the possible range of shades and textures.

9. Inspection:

9.1 Inspection of the material covered by this specification shall be carried out by the authority having jurisdiction, without notice, during the period of the Product Approval.

9.2 The tiles, as delivered to the site, shall, by visual inspection by the building official, conform to the requirements set forth in this Protocol and shall conform to samples and test reports submitted to the authority having jurisdiction. Minor indentations, chips or surface cracks incidental to the usual method of manufactures, and not extending through the body of the tile, shall not be deemed grounds for rejection.

9.3 After tiles are placed in usage, the manufacturer or his agent shall not be held responsible for compliance of the tiles with the requirements of this specification for dimensional tolerances, or color.

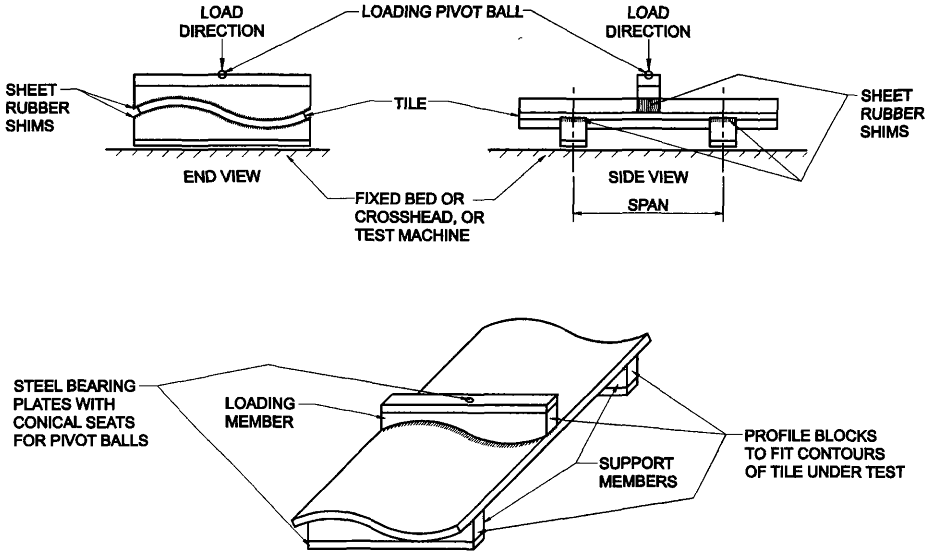
10. Rejection and Rehearing:

10.1 Material that fails to conform to the requirements of this specification may be rejected by the building official. Rejection should be promptly reported in writing to the supplier. In case of rejection, and if not specifically excluded in the purchase contract, the supplier shall have the right to inspect the rejected lot and resubmit the lot after removal of the material not conforming to the specified requirements, provided this is done with in 20 days after receipt of notice of the specific cause for rejection.

10.2 In the case the shipment fails to conform to the requirements for the type of tile specified, the manufacturer is permitted to sort it, and new specimens shall be selected by the purchaser from the retained lot and tested at the expense of the supplier. In the case the second set of specimens fails to meet the requirements, the entire shipment shall be rejected.

11. Certification:

11.1 The chief code compliance officer shall certify that the tile is in compliance with this protocol by the issuance of a Product Approval to the applicant. Tile forms part of a system that requires testing under additional protocols for usage in the high-velocity hurricane zone jurisdiction.



NOTE - SEE TEXT FOR DIMENSIONS

(POSITIONING SPRINGS FOR SUPPORT AND LOADING MEMBERS NOT SHOWN)

FIGURE 1
TRANSVERSE STRENGTH TEST APPARATUS

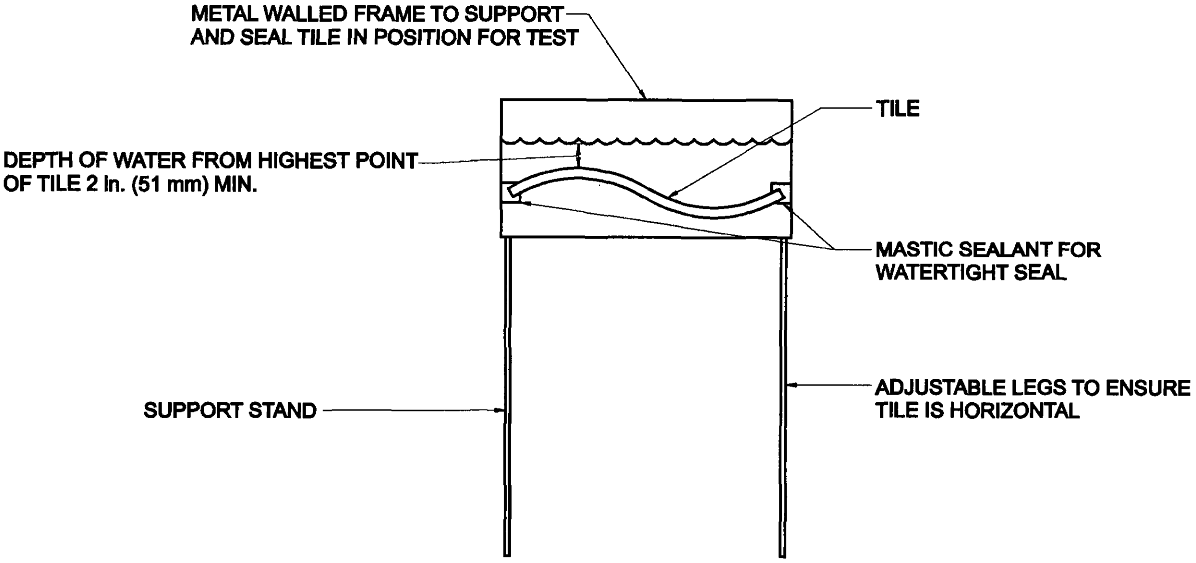

METAL WALLED FRAME TO SUPPORT
AND SEAL TILE IN POSITION FOR TEST
TILE
DEPTH OF WATER FROM HIGHEST POINT
OF TILE 2 In. (51 mm) MIN.
MASTIC SEALANT FOR
WATERTIGHT SEAL
SUPPORT STAND
ADJUSTABLE LEGS TO ENSURE
TILE IS HORIZONTAL

FIGURE 2
PERMEABILITY TEST APPARATUS

TESTING APPLICATION STANDARD (TAS) No. 112-95
Appendix A

CLARIFICATION OF TESTING FREQUENCY AND SAMPLING METHOD

1. Scope:

1.1 The purpose of this Appendix is to define frequency of testing and method of sampling.

2. Definitions:

2.1 *Domestic Manufacturers:* Those companies whose tiles are manufactured in the United States.

2.2 *Import Manufacturers:* Those companies whose tiles are manufactured outside the United States.

3. Domestic Manufacturers:

3.1 For tile lots in excess of 250,000 tiles, sampling shall be in accordance with Table 3 of TAS 112.

3.2 Tile samples shall be taken from tile inventories over 28 days old such that all tiles have an equal chance of being selected; or

3.3 Tile samples may be randomly selected from the manufacturing line and conditioned at the test lab for 28 days.

3.4 Testing shall be conducted quarterly. All sampling, testing and calculations shall be conducted by an approved testing agency. All test results, including calculations, shall be signed by a professional engineer or registered roof consultant.

4. Import Manufacturers:

4.1 For tile lots in excess of 250,000 tiles, sampling shall be in accordance with Table 3 of TAS 112.

4.2 Tile samples shall be randomly selected from tile shipments.

4.3 The frequency of testing shall be per 250,000 tiles delivered or quarterly, whichever is more frequent.

TESTING APPLICATION STANDARD (TAS) No. 114-95

TEST PROCEDURES FOR ROOF SYSTEM ASSEMBLIES IN THE HIGH-VELOCITY HURRICANE ZONE JURISDICTION

TABLE OF CONTENTS

Section 1 Scope 114-95.3

Section 2 Referenced Documents..........114-95.3

Section 3 Terminology & Units.............114-95.4

Section 4 Significance of Use................114-95.5

Section 5 General Information 114-95.5

Section 6 Applicable Documents and Glossary.................................114-95.6

Section 7 General Requirements 114-95.8

Section 8 Performance Requirements and Tests.......................................114-95.8

Section 9 Manufacturing and Field Installation Requirements..........................114-95.14

Appendix A Test Procedure for Above Deck Combustibility ASTM E 108..........................114-95.17

Appendix B Test Procedure for Simulated Dynamic Uplift Pressure Resistance of Mechanically Attached Roof System Assemblies.............................114-95.19

Appendix C Test Procedure for Simulated Uplift Pressure Resistance of Roof System Assemblies........114-95.23

Appendix D Test Procedure for Simulated Uplift Pressure Resistance of Adhered Roof System Assemblies........114-95.27

Appendix E Test Procedure for Corrosion Resistance of Fasteners, Batten Bars and Stress Distribution Plates 114-95.31

Appendix F Test Procedure for Susceptibility to Hail Damage for Roof System Assemblies.............................114-95.35

Appendix G Test Procedure for Susceptibility to Leakage for Approved Roof System Assemblies.............................114-95.37

Appendix H Test Procedure for Small Scale QC and Physical Properties of Roof System Assemblies.............................114-95.39

Appendix I Test Procedure for Static and Dynamic Puncture Resistance of Roof System Assemblies.............................114-95.41

Appendix J Test Procedure for 12' x 24' Simulated Uplift Pressure Resistance of Roof System Assemblies.............................114-95.49

Appendix K Test Procedure for F.I.T. Classification of Modified Bitumen Roof System Assemblies.............................114-95.53

TESTING APPLICATION STANDARD (TAS) No. 114-95

TEST PROCEDURES FOR ROOF SYSTEM ASSEMBLIES IN THE HIGH-VELOCITY HURRICANE ZONE JURISDICTION

1. Scope:

1.1 This protocol covers the requirements for approval of membrane roof system assemblies in the high-velocity hurricane zone jurisdiction. An approved membrane roof cover is one that meets the criteria of this protocol for accelerated weathering, corrosion of metal parts, F.I.T. [Fatigue, Indentation (dynamic and static puncture) & Temperature], fire, foot traffic, hail, leakage, and wind.

1.2 This protocol applies to any membrane roof cover intended to protect the roof assembly and building contents from the weather.

1.3 The performance of a membrane roof cover depends partially on the substrate materials over which it is applied. It is therefore necessary to evaluate the roof system assembly as a whole, including the cover and auxiliary items necessary to build up a roof system assembly. These components are included within the subject test criteria.

1.4 This Protocol is intended to evaluate only those hazards investigated, and is not intended to determine suitability for the end use of product.

1.5 This protocol evaluates roof system assemblies for their performance regarding accelerated weathering characteristics, corrosion resistance of metal parts, [(Fatigue, Indentation (dynamic and static puncture) & Temperature)], external fire (fire or burning debris from above), foot traffic resistance, susceptibility from hail storm damage, leakage, and simulated wind uplift.

1.6 Approval is based on satisfactory evaluation of the product(s) and manufacturer in the following major areas:

1.6.1 Examination and tests to evaluate: 1) the performance of the product as required by the authority having jurisdiction, and, as far as practical, 2) the marking procedures which shall be used to identify the product as set forth in Section 1517 of the *Florida Building Code, Building.*

1.7 Continued approval is based upon:

1.7.1 production or availability of the product as currently approved;

1.7.2 the continued use of acceptable quality control procedures;

1.7.3 satisfactory field experience; and,

1.7.4 compliance with the terms and conditions of the Product Approval.

1.8 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed and sealed by a professional engineer.

2. Referenced Documents:

2.1 *Florida Building Code, Building:* Chapters 15 and 16 (High-Velocity Hurricane Zones)

2.2 *Application Standards:*

TAS 105	Field Withdrawal Resistance Test Procedure
TAS 105	Field Withdrawal Resistance
Appendix A	Test Results Report

2.3 *Application Standards:*

RAS 111	Standard Requirements for Attachment of Perimeter Flashing and Woodblocking

RAS 117	Standard Requirements for Bonding or Mechanical Attachment of Insulation Panels and Mechanical Attachment of Anchor or Base Sheets to Various Substrates
RAS 137	Standard Requirements for Mechanical Attachment of Single-Ply Membrane Roof Coverings to Various Substrates

2.4 *Factory Mutual Engineering Corporation:*
Loss Prevention Data Sheet 1-7, April, 1983
Loss Prevention Data Sheet 1-28, September, 1991
Loss Prevention Data Sheet 1-28(S), November, 1991
Loss Prevention Data Sheet 1-30, May, 1990
Loss Prevention Data Sheet 1-48, June, 1991

2.5 *Factory Mutual Research Corporation Approval Standards:*

4450	Class I Insulated Steel Deck Roofs
4470	Class I Roof Covers Annual Approval Guide, 1994

2.6 *The American Society of Civil Engineers (ASCE):*
ASCE 7; Minimum Design Loads for Buildings and Other Structures

2.7 *ASTM Standards:*

A 90	Standard Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
A 641	Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
B 117	Standard Test Method for Salt Spray (Fog) Testing
D 638	Standard Test Method for Tensile Properties of Plastics
D 751	
D 1781	Standard Test Method for Climbing Drum Peel for Adhesives
E 70	Standard Test Method for pH of Aqueous Solutions With the Glass Electrode
E 108	Standard Test Methods for Fire Tests of Roof Coverings
E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)
G 23	Standard Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials
G 26	Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials
G 53	Standard Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials
G 85	Standard Practice for Modified Salt Spray (Fog) Testing

2.8 *DIN Standards:*

50018	Testing in a Saturated Atmosphere in the Presence of Sulfur Dioxide

2.9 *Norwegian Building Research Institute:*
Roof Coverings: Dynamic Wind-Load Resistance

2.10 *Roof Consultants Institute:*
Glossary of Terms

2.11 *Centre Scientifique et Technique du Batiment*
Classification for Roofing Systems

3. Terminology & Units:

3.1 Definitions—For definitions of terms used in this Protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building*; and/or Section 6.2, herein; and/or the RCI Glossary of Terms. The definitions of the *Florida Building Code, Building* shall take precedence.

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance of Use:

4.1 The requirements of this protocol are based on experience, research and testing or the standards of other national and international organizations. The advice of manufacturers, users, and trade associations is also considered.

4.2 Meeting these requirements will qualify a product as a Product Approved roof system assembly. An approved roof system assembly of itself is not a significant fire hazard when reviewed from the aspect of external fire, and can withstand expected wind uplift forces, hail stones, etc., when installed in accordance with all Product Approval requirements. Approval requirements prohibit substitution of components in the roof system assembly without a revision to the manufacturer's Product Approval. Please note that some Approvals include modified use of terminology relating to performance in hail. The High-Velocity Hurricane Zone jurisdiction is considered a moderate hail zone, as noted on the National Hailstorm Map published by the National Oceanic and Atmospheric Administration (NOAA).

4.3 Products that do not conform to these requirements may be Approved if they meet the intent of this Protocol. Conversely, those that do conform may not be Approved if other conditions prevail.

4.4 Effective date of revision:

4.4.1 The effective date of a protocol mandates that all products tested for Approval after the effective date must satisfy the requirements of that protocol. Products Approved under a previous Protocol must comply with the new version by the effective date or such date established by the chief code compliance officer or else forfeit Product Approval. The effective date may apply to the entire protocol, or, where so indicated, only to specific paragraphs of the protocol.

4.4.2 The effective date of this protocol is January 31, 1995, for full compliance with performance requirements.

5. General Information:

5.1 Roof covers:

5.1.1 Roof covers are supplied in either roll, sheet or liquid form. They may be fabricated in multi-plies (layers) or as a single ply. The single ply sheets are usually manufactured from thermoplastic materials (e.g., PVC - polyvinyl chloride); thermostat materials (e.g) EPDM - ethylene propylene diene monomers); uncured elastomer materials (e.g., PIB - polyisobutylene); or modified bitumen materials (e.g. rubberized asphalt or asphalt saturated or coated materials). The liquid covers may be supplied as silicone, polyurethane, chlorosulfonated polyethylene, acrylic, etc. Multiply systems may be various bituminous or coal tar pitch systems utilizing organic, fiberglass or polyester reinforced base, anchor or interply reinforcement.

5.2 Application of this standard:

5.2.1 To qualify as an approved roof system assembly, each assembly shall satisfy all of the following performance criteria, and be installed as tested over specific insulations and/or decks. Insulated and uninsulated deck types are listed in Product Approvals as follows:

- Wood;
- Steel;
- Concrete;
- Lightweight concrete;
- Cementitious wood fiber; and,
- Poured gypsum concrete.

5.2.2 The Approval examination includes 1) accelerated weathering;

2) corrosion resistance of metal parts; 3) F.I.T. testing which includes fatigue, dynamic and static puncture and temperature testing (F.I.T. testing is specified for modified bitumen roof membranes only; however, static and dynamic puncture testing is required for all membrane types); 4) external fire; 5) foot traffic, 6) simulated hail resistance; 7) water leakage resistance; 8) simulated wind uplift, and other tests as noted. A complete review of construction and application specifications and details shall be conducted to insure, as far as possible, a practical and reliable installation.

5.2.3 As noted in Section 4.2, approved components within a roof system assembly may not be substituted with components not listed in Product Approvals. However existing data in Product Approvals may be extrapolated, in compliance with methods set forth in RAS 117 (for insulation or base sheet attachment) or RAS 137 (for single-ply membrane attachment), to determine acceptable fastener spacings in elevated pressure zones.

6. Applicable Documents and Glossary:

6.1 Applicable documents:

6.1.1 The following standards, test methods and practices are referenced in this protocol and are summarized in the appendices herein.

- Fire tests of roof coverings - ASTM E 108, American Society for Testing and Materials
- Roof coverings: dynamic wind-load resistance, Norwegian Building Research Institute
- Uplift pressure test standard for Class I roof covers, Factory Mutual Research Corporation
- Uplift pull test standard for Adhered Class I Roof Covers, Factory Mutual Research Corporation
- Modified Salt Spay (Fog) Testing–ASTM G 85, American Society for Testing and Materials
- Testing in a Saturated Atmosphere with the Presence of Sulfur Dioxide–DIN 50018
- Susceptibility to Hail Damage Test Standard for Adhered Class I Roof Covers, Factory Mutual Research Corporation
- Susceptibility to Leakage Test for Class I Roof Covers, Factory Mutual Research Corporation
- Small Scale QC and Physical Properties Tests for Class I Roof Covers, Factory Mutual Research Corporation
- 12 foot by 24 foot Uplift Test Procedure, Factory Mutual Research Corporation
- F.I.T. Classification for Roofing Systems–Centre Scientifique et Technique du Batiment

6.2 Glossary–The following definitions shall relate to this protocol only.

Adhere: To cause two surfaces to be held together by adhesion. Single-ply membranes are often "partially-" or "totally-adhered" to a substrate with the use of contact cements, such as air-cured phenolic-neoprene mixtures, or other similar adhesives.

Ballast: An anchoring material, such as rounded river rock, gravel, or precast concrete pavers, which is used to hold single-ply roofing membranes in place and to stabilize the roof system from wind uplift forces. Although ballasting materials differ greatly in size, composition, and weight, they are typically applied at a minimum rate between 10 and 15 pounds per square foot of roof area. Thus, ballast should be applied only to those roof structures able to support this added weight.

Also, ballast materials should be large and heavy enough to resist being blown off the roof, yet light and smooth enough to avoid damaging the membrane. (Systems utilizing these applications are not generally approved in the high-velocity hurricane zone jurisdiction.)

Batten: A narrow metal band or plate, usually of galvanized steel or aluminum, which is used to fasten or hold in place a single-ply membrane, to prevent its displacement.

Delamination: Separation of the plies in a roof membrane or system in any laminated roofing material or component, e.g., laminated layers of rigid insulation or the felt plies in a built-up roof.

Disc Fasteners: A wide variety of devices of mechanical assemblies used to attach single-ply membranes, insulation boards and/or base sheets to a substrate or deck. Disc attachments generally consist of a square- or circular-shaped plate with a hole in the center, through which a screw or nail-like clip may be inserted. They are generally set in place with a drill-like device.

EPDM: Designated nomenclature for a tripolymer of ethylene, propylene, and diene.

Field Seam: A splice made in the field which joins two sheets together using an adhesive splicing tape, or heat- or solvent-welding.

Heat Welding: A process or method of melting and sealing or fusing the overlapping edges of separate sections of thermoplastic or uncured elastomeric roofing membranes by the application of heat and pressure. Small, portable "hot air" or "heat welding" devices are available which can, without the use of chemicals or adhesives, heat seal or fuse together overlapping edges to form waterproof seams.

Loosely Laid: Membranes which are not attached to the substrate except at the perimeter of the roof and at projections. Loosely laid membranes are held in place with appropriate and adequate ballast, such as round river washed stone, gravel, pavers, etc. This assembly may be used only on roof structures able to support the added weight of the ballast, which is generally applied at a minimum rate of 10 pounds per square foot of roof area. (These systems are not generally approved in the high-velocity hurricane zone jurisdiction.)

Mechanically Fastened Membrane:
Generally used to describe single-ply membranes which have been positively attached at intervals to the substrate, usually with various fasteners and other mechanical devices such as battens. Mechanical fastening permits the membrane to float free between the fasteners, and allows greater movement between the membrane and the substrate than in fully adhered systems.

Modified Bitumen:
A material consisting of bitumen which has been modified through the inclusion of one or more polymers and may contain stabilizers and other additives. Modified bitumen roofing membranes may also contain a reinforcing material.

Partially Adhered:
A roofing assembly in which the membrane has been "spot affixed" to a substrate, usually with an adhesive, such as contact cement, or a mechanical device.

Polyisobutylene (PIB):
A synthetic uncured elastomer produced by the copolymerization of isobutylene and isoprene. PIB roofing membranes are composed of polyisobutylene, and various other reinforcing fillers and stabilizers.

Polyvinylchloride (PVC):
A thermoplastic polymer, synthesized from vinyl chloride monomer. Membranes containing polyvinyl chloride are used in single-ply roofing membranes.

Self-Adhesive Membranes:
Single-ply membranes which can adhere to a substrate and to itself at overlaps without the use of an adhesive. The undersurface of a self-adhesive membrane is protected by a "release paper" that prevents the membrane from bonding to itself during shipping and handling. Later, as the membrane is unrolled, the release paper is peeled away, and the self-adhering undersur-

face is applied to the substrate. Successful application of a self-adhesive membrane requires a clean and dry substrate and the application of firm, uniform pressure.

Single-Ply Membranes:
Roofing membranes that are field applied using just one layer of membrane material (either homogenous or composite) rather than multiple layers. However, the manufacture of the single-ply sheeting may involve lamination or several layers of the same or different materials.

Thermoplastic: Polymers that soften when heated and harden when cooled. This process is repetitive provided the material is not heated above the point at which decomposition occurs.

Thermoset: A material that solidifies or "sets" irreversibly when heated. This property is usually associated with crosslinking of the molecules induced by heat or radiation.

TPO: Designated nomenclature for thermoplastic olefin elastomer based single-ply sheets made from blends of polypropylene and ethylene-polypylenene rubber.

Wind Uplift: The force generated by wind on a roof system or components in a roof system resulting from wind-induced pressures. Wind that is deflected around and across the surfaces of a building causes a drop in air pressure immediately above the roof surface. As a result, the air in the building will flow beneath the membrane and roof deck and tend to lift the roof upward. Wind uplift may also be caused by the introduction of wind underneath the membrane and roof edges, where it can cause the membrane to balloon and pull away from the substrate. Roof loss by wind can be avoided or prevented by proper installation and adequate adhesion, attachment, or ballasting.

7. General Requirements:

7.1 During the initial investigation and before physical testing, the manufacturer's specifications and details shall be reviewed to assess the ease and practicality of installation and use. Confirmation of specifications and details are assessed through an inspection of a field application or through viewing of a video of an application which includes all pertinent areas of the application. The product shall be capable of being used within the limits of the Approval investigation.

7.2 Markings:

7.2.1 Packaging material and/or containers shall bear the manufacturer's name and product identification in compliance with provisions set forth Section 1517 of the *Florida Building Code, Building*.

7.2.2 Product shall be marked by embossing, painting or cutting in compliance with *Florida Building Code, Building* requirements.

7.3 Instructions:

7.3.1 Printed, published installation instructions shall be provided by the manufacturer to demonstrate proper installation procedures to be followed by installers. As part of the approval examination, at least one inspection of a field installation, during and/or after its completion, shall be required. In some cases, a continued program of inspections shall be necessary to assess the application procedures or changes within the application techniques.

7.3.2 Review of a Factory Mutual Approval Report and/or the listing of the roof system assembly in the current edition of the Factory Mutual Approval Guide may be, at the discretion of the chief compliance officer, sufficient evidence of compliance with any portion of this protocol.

8. Performance Requirements and Tests:

8.1 General

8.1.1 This protocol is intended to evaluate a roof system assembly for its performance as it relates to accelerated weathering, corrosion of metal parts, F.I.T. performance (Fatigue, Indentation and Temperature), fire, foot traffic, hail, leakage, and wind. The applicant may submit up to five roof system assemblies in its Application for Product Approval. The chief code compliance officer shall respond, in writing, stating which tests shall be required for sufficient evidence of compliance.

8.2 Combustibility:

Note: Roof adhesives effect the potential fire spread properties of a roof system assembly. In addition, combustible adhesives are susceptible to ignition during roof construction and cure periods. Therefore, fire testing shall be done after a minimum 28 day cure period.

8.2.1 External fire testing shall be in strict compliance with ASTM E 108, as noted in Appendix A herein.

8.2.2 Testing shall include:

- spread of flame;
- intermittent flame;
- burning brand; and
- flying brand

tests as applicable.

8.2.3 Tests of alternate constructions may be waived by the chief code compliance officer if considered less hazardous than those previously tested.

8.2.4 During these tests, there shall be no flaming or burning particles blown off the test assembly and reaching the floor.

8.3 Wind resistance:

Note: Perimeter flashing, including metal components, shall be in fabricated and installed in compliance with RAS 111 for all approved roof system assemblies.

8.3.1 Totally or partially adhered roof system assembly:

8.3.1.1 Requirements:

- The adhesive(s) used to bond insulation and/or roofing plys or membrane shall penetrate or adhere to the substrates sufficiently to establish an adequate bond without degradation of the insulation. It shall be sufficiently fluid for effective application in accordance with the manufacturer's directions. In addition, the application shall not be adversely affected by temperature extremes. Applications within the *Florida Building Code, Building* jurisdiction generally take place at temperatures above 70°F (21°C).
- The adhesives shall achieve substantial adhesion with the insulation and at the laps within a minimum specified time such that winds will not lift the covering and/or insulation before the adhesive bond has fully developed. The solids within the adhesive shall generally remain in suspension. Any settlement must be redispersed after 5 minutes of agitation. Adhesives shall be designed and formulated to facilitate reliable field application according to the manufacturer's specifications. All adhesives shall be labeled

with maximum 'open' time in a high temperature, high humidity climate to reduce the chance of application spoiled adhesive.

8.3.1.2 Simulated uplift testing

- After a 4 day laboratory cure time at ambient conditions, the totally or partially adhered roof system assembly shall be initially tested for uplift resistance in compliance with the test procedures outlined in Appendix C, D, H or J, herein. The roof system assembly shall attain a passing load not less than 30 psf (1.5 kPa). Thereafter, the roof system assembly test specimen shall be allowed to cure for the remaining cure time. Failure to meet this initial four (4) day cure time uplift criteria shall result in failure of the roof system assembly and no further testing shall be conducted.
- After the remaining laboratory cure time, the totally or partially adhered roof system assembly shall be tested for uplift resistance in compliance with the test procedures outlined in Appendix C, D or J, herein.

8.3.2 Mechanically attached roof system assembly:

8.3.2.1 Mechanically attached roof covers are held in place by "single-type" or "batten type" fastener assemblies.

- "Single-type" fastener assemblies include a fastener accompanied by a stress distribution plate which is installed in a specific pattern to secure roofing components within a roof system assembly. Stress plates are available in a variety of shapes and sizes, each of which may provide differing uplift resistance results when installed with the same fastener in an identical pattern. They may be: 1) installed under the roof cover with adhesive applied to the top surface of the plate; 2) installed through the roof cover and sealed; 3) installed within the lap as the covering is being installed; or, 4) installed under the roof cover with an integral fastener above (non-piercing types).
- "Batten-type" fastener assemblies have a long bar or batten strip through which the fasteners are driven. They are usually installed: 1) through the roof cover with a patch or sealant applied over the batten; 2) as the cover is being installed within the lap; or, 3) under the roof cover with an integral fastener applied over the cover (non-piercing type).

8.3.2.2 Requirements:

- Fasteners and stress plates shall be tested in compliance with the requirements set forth in TAS 117, Appendices A, B and C.

- All fasteners, other than base ply fasteners, shall record a withdrawal resistance value under static load greater than or equal to 275 lbf (1220 N) and a withdrawal resistance value under pulsating load greater than or equal to 175 lbf (778 N) when tested in compliance with Appendix A of TAS 117.
- Fasteners shall be of proper length to penetrate the roof deck, if applicable. For steel deck application, fasteners must penetrate the top flange. Fasteners shall hold securely in the structural deck and prevent the covering from being lifted off. The fastening system shall secure the insulation in place under the roof cover. (Preliminary fasteners shall be used to maintain the insulation in place under the cover. See RAS 117.) If fasteners are installed within the lap, they shall be installed so as not to weaken the field seam. Any separation or delamination at the field seam that would require remedial measures shall be considered a failure. Materials and design shall be adequate to prevent fastener failure. The design must insure permanent securement to the deck, resisting horizontal and vertical deck movement due to temperature changes, live loads on the roof, and to vibration.
- The fastener shall be capable of proper installation with the recommended equipment without damage to the roof cover. The fastener application density or spacing shall be initially verified through simulated uplift pressure testing, as noted in Section 8.3.2.3, herein. Data extrapolation for fastener density or spacing shall be conducted in strict compliance with RAS 117 (for insulation or base sheet attachment) or RAS 137 (for single-ply membrane attachment). Data extrapolation is limited by the test method utilized for simulated uplift testing. (See Section 8.3.2.3, herein.)
- A minimum of two approved insulation fastener assemblies are required for preliminary attachment of insulation panels having dimensions less than or equal to 4 feet by 4 feet (1.2 m by 1.2 m). A minimum of four approved insulation fastener assemblies are required for preliminary attachment of insulation panels having dimensions greater than to 4 feet by 4 feet (1.2 m by 1.2 m).

8.3.2.3 Simulated uplift testing:

- Mechanically attached Roof System Assemblies shall be tested using one or more of the test procedures outlined in Appendices B, C, and/or J.

- The test procedure outlined in Appendix B is a dynamic uplift test utilizing a dynamic wind chamber for testing of all mechanically attached roof system assemblies having a maximum fastener row spacing of 72 inches. Appendix B simulated uplift testing generates a fastener assembly design value and a maximum allowable fastener density or spacing. This maximum allowable fastener density or spacing may be altered through data extrapolation, in compliance with RAS 137 (for single-ply membrane attachment), to meet design pressures for a specific building.
- The test procedure outlined in Appendix 'C' is a static uplift test utilizing a 5 foot by 9 foot (1.5 m by 2.7 m) pressure vessel for testing of mechanically attached roof systems assemblies with a row spacing less than or equal to 48 inches (1.2 m) o.c. or a fastener grid spacing less than or equal to 12 inches by 24 inches (0.6 m by 1.2 m); (8 square feet per attachment point). The roof system assembly shall attain a passing load not less than 90 psf (4.2 kPa). Data generated from Appendix C simulated uplift testing may not be used for extrapolation.
- The test procedure outlined in Appendix J is a static uplift test utilizing a 12 feet by 24 feet (3.6 m by 7.6 m) pressure vessel for testing of mechanically attached roof systems assemblies with a row spacing greater than 48 inches (1.2 m) o.c. or a fastener grid spacing greater than 12 inches by 24 inches (0.6 m by 1.2 m); (8 square feet per attachment point). The roof system assembly shall attain a passing load not less than 90 psf (4.2 kPa). Data generated from Appendix J simulated uplift testing may be used for extrapolation, in compliance with RAS 137 (for single-ply membrane attachment), to meet design pressures for a specific building. Extrapolation of data from Appendix J simulated uplift testing is limited to 1.75 times the maximum uplift pressure noted in the Product Approval.
- The chief code compliance officer may, at his/her option, accept and publish in Product Approvals roof system assemblies that do not meet the minimum 90 psf (4.2 kPa) uplift criteria providing the manufacturer has one or more assemblies that meet the minimum uplift criteria.

8.4 Corrosion Resistance:

8.4.1 Nails and carbon steel fasteners:

8.4.1.1 All nails and carbon steel fasteners shall be tested for corrosion resistance in compliance with ASTM Standard Practice G 85 [(Modified Salt Spray (Fog) Testing)], Annex A5 (Dolute Electrolyte Cyclic Fog/Dry Testing) as modified for the high-velocity hurricane zone and noted in Section 2 of Appendix E, herein.

8.4.2 Batten bars, stress distribution plates and fasteners (other than nails):

8.4.2.1 All batten bars, stress distribution plates, and metal fasteners (other than nails) shall be tested for corrosion resistance in compliance with DIN 50018 as noted in Section 3 of Appendix E, herein.

8.4.2.2 Each specimen shall be exposed to air saturated with water vapor (104°F, 40°C) containing a mild concentration of sulfur dioxide for 8 hours, followed by a drying period of 16 hours at room temperature. After each drying cycle, the specimen shall be inspected and signs of corrosion or rust shall be recorded.

8.4.2.3 The 24-hour cycle shall be repeated 15 times and the corrosion percentage shall be recorded.

8.4.2.4 To evaluate the corrosion increase after Cycle 1 through Cycle 15, the specimen shall be mounted to blue painted sheet backdrop.

8.5 Hail resistance:

Note: The high-velocity hurricane zone jurisdiction is a 'moderate hail' area, as designated by the National Oceanic and Atmospheric Administration (NOAA).

8.5.1 The roof system assembly shall be tested for hail damage resistance in compliance with either of the Simulated Hail Damage Test procedures noted in Appendix F, herein. A minimum of ten drops from the impactor is required, five of which shall be conducted in a field-fabricated seam or flashing detail where appropriate.

8.5.2 The roof cover and the field seam shall not show signs of cracking, splitting, internal separation, delamination, or rupture. Under adhered conditions, minor separation of the roof cover from the substrate (directly under the impact area) is acceptable performance for monolithic decks only (e.g. lightweight concrete, structural concrete, and gypsum, etc.). Severe degradation, such as cracking, crushing, etc., of the deck itself is reason for failure. The cover thickness shall be checked at the points of impact.

8.6 Water leakage:

8.6.1 The roof cover shall be tested for water leakage resistance in compliance with the Water Leakage Test procedures noted in Appendix G, herein. A sample 18 inches (45 cm) in diameter shall be prepared and, where appropriate, a field seam and/or penetration detail shall be included. The sample shall be conditioned (weathered) for 1000 hours in a fluorescent ultraviolet condensation type weathering apparatus before being cut into a size 10 inches (25 cm) in diameter and placed in the leakage test apparatus. The sample shall be maintained at ambient conditions.

8.6.2 The roof cover and field seam and/or penetration detail shall not show signs of a leakage during or at the end of the 7 day period.

8.7 Accelerated weathering:

8.7.1 Accelerated weathering testing shall be in strict compliance with ASTM G 23 or G 26.

8.8 F.I.T. Testing (F = Fatigue, I = Indentation, T = Temperature):

Note: Complete F.I.T. testing is required for modified bitumen roof membranes only; however, static and dynamic puncture resistance testing, which forms a part of F.I.T., is required for all membrane types.

8.8.1 Fatigue:

8.8.1.1 Fatigue testing of modified bitumen roofing membranes shall be in compliance with the test procedures outlined in Appendix K, herein.

8.8.2 Static and dynamic puncture:

8.8.2.1 Static and dynamic puncture resistance testing shall be in strict compliance with the test procedures outlined in Appendix I, herein.

8.8.3 Temperature:

8.8.3.1 Temperature testing of modified bitumen roofing membranes shall be in compliance with the test procedures outlined in Appendix K, herein.

8.9 Resistance to foot traffic:

8.9.1 Resistance to foot traffic testing shall be in strict compliance with the test procedures outlined in this section.

8.9.2 Test:

8.9.2.1 A 3 inch (76 mm) square steel plate with rounded corners shall be centered on the centerline of a 12 inch (305 mm) square horizontal panel and positioned along the butt edge and side joint of the insulation boards.

8.9.2.2 A 200 lbf (889 N) load shall be imposed on the plate. The superimposed load shall be reduced to zero and the sample cover reloaded a minimum of four additional times, with penetration and residual readings taken each time without removing the plate. The specimen shall be inspected after the test and the condition of the cover noted at the steel plate interface.

8.9.2.3 Tearing or cracking of the protective coating causing exposure of the plastic, glass fibers, foam or other compressible core material shall be unacceptable.

9. Manufacturing and Field Installation Requirements:

9.1 Demonstrated QC Program:

9.1.1 A Quality Control Program is required to insure that subsequent roof covers produced by the manufacturer shall present the same quality and reliability as the specific roof cover samples examined. Design quality, conformance to design and performance are the areas of primary concern. Design quality is determined during the examination and tests, and is covered in the Product Approval. Conformance to design is verified by quality control in the following areas:

- Existence of corporate quality control guidelines;
- Incoming inspection and testing;
- In-process inspection and testing;

- Final inspection and testing;
- Equipment calibration;
- Drawing and change control; and,
- Packaging and shipping

9.1.2 Quality of performance is determined by field performance and by periodic re-examination and testing.

9.1.3 The manufacturer shall establish a system of product configuration control to prevent unauthorized changes, including the following, as appropriate:

- Engineering drawings;
- Engineering change requests;
- Engineering orders; and/or,
- Change notices

These shall be implemented through policy and detailed procedures to implement engineering change requests, orders or change notices; and records of all revisions to all approved products shall be kept.

9.2 Inspection procedures:

9.2.1 At manufacturing plant:

9.2.1.1 An inspection of the product manufacturing facility may be part of the approval application. Its purpose shall be to determine that equipment, procedures, and the manufacturer's quality controls are properly maintained to produce a product of the same quality as initially tested.

9.2.1.2 Periodic, unannounced follow-up inspections may be conducted to insure continued quality control and product uniformity.

9.2.1.3 The chief code compliance officer may rely on continued listing of approved systems in the annual Factory Mutual Approval Guide and quarterly supplements as confirmation of requirements under this section.

9.2.2 At site of installation:

9.2.2.1 Field inspections may be conducted to review roof system assembly installations. The inspections shall be conducted to assess ease of application, workability, and conformance to written specifications and details. When more than one application technique is used, one or all may be inspected.

9.2.2.2 The chief code compliance officer shall review established procedures from recognized testing and listing agencies to confirm compliance with the requests set forth herein.

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX A

TEST PROCEDURE FOR ABOVE DECK COMBUSTIBILITY
ASTM E 108

1. Scope:

1.1 Flame propagation over the exterior surface of a roof system assembly is dependent on the rate at which the fuel is liberated from the test sample. The extent of spread and speed of propagation is influenced not only by the roof cover, but also by the substrate insulation and slope. Therefore, it is necessary to select constructions for evaluation that will demonstrate the performance of the roof cover when applied to a variety of roof insulation materials.

1.2 The applicant shall submit in the initial application all roof system assemblies requested over combustible and noncombustible decks. From this submission, the chief code compliance officer may list a limited number of roof system assemblies which will require external fire testing to represent all proposed assemblies.

1.3 Alternatively, the applicant may submit copies of its listing(s) from Underwriters Laboratories' Annual *Roofing Materials and Systems Guide*, Warnock Hersey's Annual *Certification Listing Guide*, and/or Factory Mutual Research Corporation's Annual *Approval Guide* or Quarterly *Supplement Approval Guide* to confirm those assemblies tested in compliance with ASTM E 108 (or UL 790). Copies of test reports from these organizations, or any other approved testing agency, are also acceptable.

2. Test Procedure:

2.1 The above deck combustibility tests shall be conducted in strict compliance with ASTM E 108 test procedure.

2.2 Testing in compliance with ASTM E 108 yields the following external fire ratings:

- Class 'A' external fire tests are applicable to roof coverings that are effective against severe exposure to external fire, afford a high degree of fire protection to the roof deck, do not slip from position, and do not present a flying brand hazard.
- Class 'B' external fire tests are applicable to roof coverings that are effective against moderate exposure to external fire, afford a moderate degree of fire protection to the roof deck, do not slip from position, and do not present a flying brand hazard.

2.3 A rating of Class 'A' or 'B' shall be obtained. Use of a Class 'C' external fire rated roof system assembly is extremely limited in the high-velocity hurricane zone jurisdiction.

2.4 Refer to Section 1516 of the *Florida Building Code, Building* for fire resistance roof covering requirements.

3. Evaluation of Results:

3.1 A minimum external fire rating of Class 'B' is required for approval of any roof system assembly.

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX B

TEST PROCEDURE FOR SIMULATED DYNAMIC UPLIFT PRESSURE RESISTANCE OF MECHANICALLY ATTACHED ROOF SYSTEM ASSEMBLIES

1. **Scope:**

1.1 Loads incurred on roof systems assemblies generated from external wind, in combination with internal pressure, are dynamic in nature.

1.2 Damage incurred by the effects of wind over and internal pressure under a mechanically attached roof system assembly generally results in failure of the fastener/substrate combination, the fastener/insulation combination or the fastener/roof cover combination.

1.3 Thus, the dynamic nature of external wind and internal pressure loading on mechanically attached roof system assemblies, in combination with incurred damage to these assemblies, suggests that an instrument designed to measure the stability of roof system assemblies be equipped to evaluate fastener withdrawal from the substrate, roof cover blow-off from the substrate, the influence of the airtightness of the substructure on load transfer to the fasteners, and the effects of fastener fatigue when subjected to dynamic loading. The Dynamic Uplift Pressure Test Procedure has been designed for this purpose.

1.4 Testing under this test method is limited to mechanically attached roof system assemblies having a fastener row spacing not greater than 72 inches.

2. **Terminology**–the following definitions apply to the test procedure outlined herein.

2.1 P = the static positive pressure applied as a uniform load on the roof system assembly underside while dynamic loading is being applied from below.

2.2 Pd = the dynamic negative pressure ap plied as gusts of suction to the storage tank; the suction is noted as the instantaneous pressure measured at the air intake slit above the roofing membrane (see Figure B1, herein).

2.3 Failure = roof system assembly failure under this test standard could be one or more of the following:

- withdrawal or breakage of fasteners;
- tearing, splitting or other breakage of the roof cover at the point(s) of attachment;
- impairment of the waterproofing function of the roof systems assembly; or,
- permanent deformation of the roof cover or fastener assembly, including stress plate, which may reduce the waterproofing function of the roof system assembly over time.

3. **Apparatus:**

3.1 The test apparatus for determining dynamic wind-load resistance is shown in Figure B1, herein.

4. **Test Limitations and Precautions:**

4.1 Testing under this test method is limited to mechanically attached roof system assemblies having a fastener row spacing not greater than 72 inches.

4.2 During the test, all testing agency representatives and other test observers shall wear ear and eye protection and hard hats to prevent injury.

4.3 This test procedure may involve hazardous materials, operations and equipment. This protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Test Specimens:

5.1 The test specimen(s) shall be constructed in compliance with the manufacturer's current, published installation specifications and details for the roof system assembly under consideration for approval. If the fastener density or spacing for the roof system assembly varies, those having the lowest number of attachment points shall be tested.

5.2 Roof system assemblies whose wind-load resistance performance may be affected by bad weather conditions during installation shall be constructed in a manner which simulates actual working conditions.

6. Test Procedure:

6.1 Principal:

6.1.1 The roof system assembly test specimen is mounted between two air-tight boxes. A pressure difference is applied across the test specimen. Subsequent increasing pressure differences are applied until failure occurs.

6.2 A constant, positive static pressure (P) of 15 psf (718 Pa) shall be applied to the underside of the test specimen during all dynamic pressure intervals. This constant, positive static pressure shall be applied from the lower box of the test apparatus. See Figure B1, herein.

6.3 The dynamic pressure (Pd) is applied as gusts of suction in a $1^1/_8$ inches (30 mm) slit positioned above the roof cover and between fastener rows where insulation has been removed, resulting in initial upward deflection of the roof cover and non-axial loading at attachment points.

6.4 The dynamic pressure (Pd) gusts, as measured at the air intake slit above the roof cover, are applied in 60 minute time intervals with each interval having increasing pressure gusts as noted in Table B1, below.

6.5 Subsequent to each dynamic pressure interval, the apparatus shall be turned off and the test specimen shall be inspected for signs of failure.

6.6 The passing load interval shall be that which the roof system assembly resisted dynamic pressure (Pd) and static pressure (P) without failure for the 60 minute duration. The maximum allowable fastener density or spacing shall be that which was utilized in test specimen construction.

7. Calculations:

7.1 Determine the maximum uplift pressure (Pm):

7.1.1 The maximum uplift pressure shall be the passing dynamic pressure (Pd) interval, recorded subsequent to testing, plus the static pressure (P) applied to the underside.

$Pm = Pd + P$ where,

Pm = maximum uplift pressure (psf);

Pd = passing dynamic pressure (psf); and,

P = static pressure = 15 psf.

TABLE B1
DYNAMIC PRESSURE GUST INTERVALS

Load Interval[1]	Dynamic Pressure (Pd)	Load Interval[1]	Dynamic Pressure (Pd)
1	15 psf (718 Pa)	6	90 psf (4309 Pa)
2	30 psf (1436 Pa)	7	105 psf (5027 Pa)
3	45 psf (2154 Pa)	8	120 psf (5745 Pa)
4	60 psf (2872 Pa)	9	135 psf (6437 Pa)
5	75 psf (3590 Pa)	etc.	etc.

[1] Each load interval is 60 minutes long consisting of dynamic pressure gust loading every 15 seconds.

7.2 Determine the fastener assembly design value (dv) using the maximum uplift pressure (Pm), achieved during testing, and the maximum allowable fastener density or spacing utilized for test specimen construction.

$$dv = \frac{Pm \times l \times w}{n}$$ where,

dv = fastener assembly design value (lbf);

Pm = maximum uplift pressure (psf);

l = length of test specimen (ft);

w = width of test specimen (ft); and,

n = number of fasteners.

8. Interpretation of Results:

8.1 The maximum allowable fastener density or spacing utilized for test specimen construction relates directly to the maximum uplift pressure (Pm), determined in Section 7.1.

8.2 A 2:1 margin of safety shall be applied to the maximum uplift pressure (Pm) determined in Section 7.1.

8.3 The fastener assembly design value (dv) determined from dynamic uplift testing may be used to alter the maximum allowable fastener density or spacing through data extrapolation, in compliance with RAS 137 (for single-ply membrane attachment), to meet design pressures for a specific building. Only 'upward' extrapolation is acceptable (i.e. fastener density may not be decreased and fastener spacing may not be increased for lesser design pressures).

9. Report:

9.1 The final test report shall include the following:

9.1.1 A description of the roof system assembly test specimen, including the manufacturer of all components, a description of all components and the method of test specimen construction (including the fastener density or spacing).

9.1.2 A copy of the published application instructions provided by the roof system assembly manufacturer.

9.1.3 A description of the test apparatus.

9.1.4 A record of all observations noted during inspections subsequent to each dynamic pressure interval, including the final mode of failure.

9.1.5 The dynamic pressure interval, and time within the interval, at which the test specimen failed. If failure was not observed until the end of the dynamic pressure interval, record only the 'failure interval.'

9.1.6 A copy of the calculations from Section 7 and the results thereof.

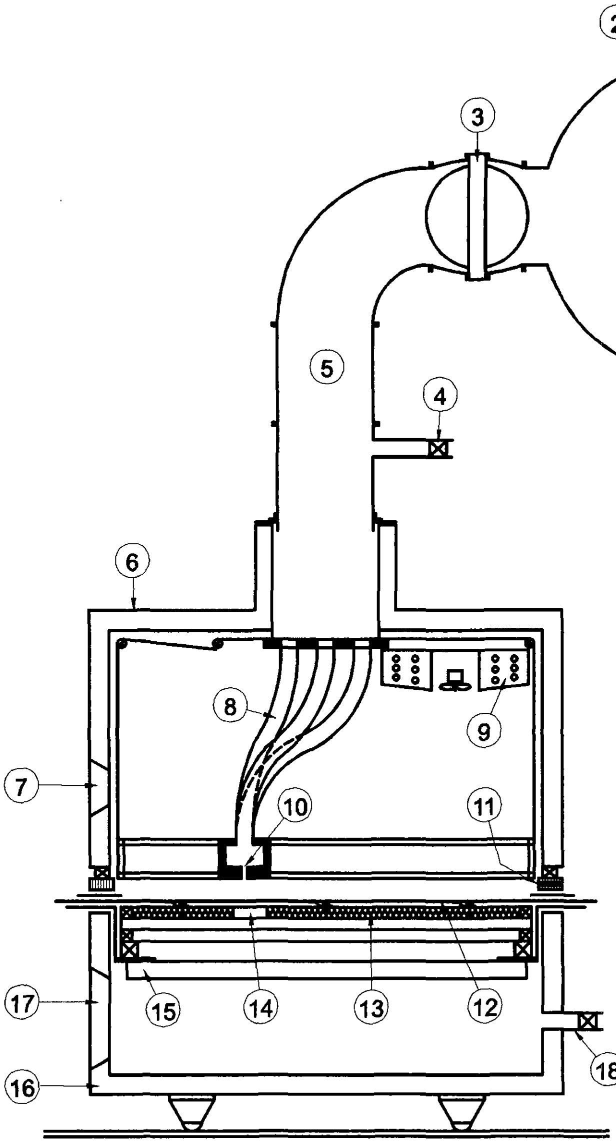


FIGURE B1
DYNAMIC UPLIFT TEST APPARATUS

1. Storage tank (388 cubic feet) for air at low pressure
2. Connection to fan for air evacuation
3. Valve to operate dynamic suction
4. Connection to fan operating pulsating suction for standard wind load testing
5. Main air duct
6. Upper box
7. Inspection window
8. Flexible air tubes (7 with 6-inch diameter)
9. Air cooler
10. $1^1/_8$ inch: air intake slot
11. Holes to equalize pressure after gust
12. Roof cover with fasteners
13. Roof deck with insulation
14. Section without insulation
15. Steel frame
16. Lower box
17. Inspection manhole
18. Connection to fan operating static pressure for standard wind load testing.

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX C

TEST PROCEDURE FOR SIMULATED UPLIFT PRESSURE RESISTANCE OF ROOF SYSTEM ASSEMBLIES

1. **Scope:**

1.1 Damage incurred by the effects of wind over and internal pressure under a totally adhered, partially adhered or mechanically attached roof system assembly generally results in one or more of the following:

- Uplift of the cover (when totally adhered);
- Delamination within the roof insulation cover (when totally or partially adhered);
- Failure of adhesive between the insulation and the deck or between the insulation and the vapor retarder and/or between the vapor retarder and the deck; and,
- Failure of the fastener/substrate, fastener/insulation or fastener/roof cover combination.

1.2 Thus the nature of the damage incurred would suggest that an instrument designed to measure the stability of roof assemblies be equipped to evaluate bond strength indicated in the items above. The Uplift Pressure Test has been designed for this purpose.

1.3 This procedure is not applicable to mechanically attached roof system assemblies having a batten or fastener row spacing greater than 48 inch (1.2 m) o.c. or a spot/grid attachment density greater than 8 square feet (0.7432 m^2) per fastener.

2. **Terminology**–the following definitions apply to the test procedure outlined herein.

2.1 Failure: Roof system assembly failure under this test standard could be one or more of the following:

- withdrawal or breakage of fasteners;
- tearing, splitting or other breakage of the roof cover at the point(s) of attachment;
- impairment of the waterproofing function of the roof systems assembly (i.e. cracking of components within the assembly);
- permanent deformation of the roof cover or fastener assembly, including stress plate, which may reduce the waterproofing function of the roof system assembly over time; and,
- delamination or separation of adhered areas.

3. **Apparatus:**

3.1 The uplift pressure apparatus is a steel pressure vessel arranged to supply air pressure at pre-established standard rates to the underside of the roof system assembly test specimen which forms the top of the test apparatus.

3.2 The pressure vessel measures 9 feet long by 5 feet wide by 2 inches deep (2.7 m by 1.5 m by 51 mm) (See Figures C1 and C2, herein).

3.3 A $^3/_4$ inch (19 mm) opening is supplied in one 9 foot (2.7 m) side for an air supply inlet. A $^1/_4$ inch (6 mm) opening in the opposite 9 foot (2.7 m) side serves as a manometer connection. A rubber gasket that lies between the top angle of the pressure vessel and the test assembly minimizes air leakage when the sample is clamped on.

3.4 Air pressure is supplied through the use of an air compressor (5 horse power electric motor, 1200 rpm) in conjunction with a 21 foot (6.4 m) section of 12 inch (305 mm) pipe which serves as a reservoir. Pressure readings are obtained from a water-filled, or other type of, manometer, calibrated to read directly in pounds per square foot (kg/m^2).

4. Test Limitations and Precautions:

4.1 During the test, all testing agency representatives and other test observers shall wear ear and eye protection and hard hats to prevent injury.

4.2 This test procedure may involve hazardous materials, operations and equipment. This protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Test Specimens:

5.1 The components for a proposed test panel are assembled to the desired specifications and details (gauge of steel, application method and rate for the adhesives or fasteners, size and thickness of insulation, type of cover) and then left to "cure" for a specified time period.

5.1.1 Test specimens assembled in hot asphalt shall be allowed to cure for not less than 24 hours prior to testing.

5.1.2 Test specimens assembled in cold adhesive shall be allowed to cure for not less than 28 days prior to testing, with the exception of the preliminary four day testing noted in Section 8.3.1.2 of TAS 114.

5.1.3 Test specimens assembled over lightweight concrete deck substrates shall be constructed seven days after the deck is poured and shall be tested on the 28th day.

5.2 If the test specimen is a totally or partially adhered roof system assembly, the test specimen shall be tested to 30 psf (1.4 kPa) after a 4 day laboratory cure time at ambient conditions. If the test specimen fails to resist this initial test pressure, the test shall be discontinued. Upon passing this initial testing, the test specimen shall be allowed to cure for the remaining cure time.

5.3 When ready for testing, the panel is placed on top of the uplift pressure apparatus. A $^{7}/_{8}$ inch (22 mm) thick, 2 inch (51 mm) wide board is placed around the perimeter of the sample followed by 2 inch by 3 inch (51 mm by 76 mm) metal angles (smaller dimension horizontal). Five C-clamps are securely attached on each 9 feet (2.7 m) edge three along each 5 foot (1.4 m) edge. The appropriate hose connections are then made to the air supply and manometer.

5.4 Not less than three test specimens shall be constructed for each roof system assembly being tested.

5.5 Roof system assemblies whose wind-load resistance performance may be affected by bad weather conditions during installation shall be constructed in a manner which simulates actual working conditions.

6. Test Procedure:

6.1 Principal:

6.1.1 The roof system assembly test specimen is mounted on the test apparatus. A pressure difference is applied across the test specimen. Subsequent increasing pressure differences are applied until failure occurs. Three roof system assembly test specimens shall be tested and the average passing load reported.

6.2 After the test specimen is mounted on the test apparatus, compressed air is introduced beneath the sample in accordance with Table C1, below:

TABLE C1
UPLIFT PRESSURE INTERVALS

Time (Minutes)	Static Uplift Pressure	
	psf	kPa
0:01 to 1:00	30.00	1.40
1:01 to 2:00	45.00	2.20
2:01 to 3:00	60.00	2.90
3:01 to 4:00	75.00	3.60
4:01 to 5:00	90.00	4.20
5:01 to 6:00	105.00	4.90
6:01 to 7:00	120.00	5.70
7:01 to 8:00	135.00	6.50
8:01 to 9:00	150.00	7.20

[1] Add 15 psf (0.7 kPa) for each successive one minute interval.

6.3 Prior to and during the attainment of the uplift pressures noted above, the test specimen is examined for failure. Upon failure, the test specimen is dismantled and examined to determine the exact mode of failure.

6.4 Record the mode, time and pressure interval of failure.

6.5 Repeat Sections 6.2 through 6.4 for each of three test specimens.

7. Interpretation of Results:

7.1 The passing uplift pressure shall be the average of the three pressures which the test specimens resisted for one minute without failure. If one or more of the three tests yields a passing uplift pressure greater or less than 15 percent of other recorded values, an additional test shall be conducted.

7.2 The minimum passing uplift pressure for an approved roof system assembly shall be 90 psf (4.2 kPa).

7.3 A 2:1 margin of safety shall be applied to the passing uplift pressure prior to inclusion in the system manufacturer's Product Approval.

7.4 Average wind velocities can vary considerably from area to area. The *Florida Building Code, Building* utilizes a windspeed as noted in Section 1620.2. These wind velocities in miles per hour are related to the design pressure, in pounds per square feet (kg/m^2), for a particular building. Refer to Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* and ASCE 7.

7.5 No extrapolation of resulting data will be accepted.

8. Report:

8.1 The final test report shall include the following:

8.1.1 A description of the roof system assembly test specimen, including the manufacturer of all components, a description of all components and the method of test specimen construction (including the fastener density or spacing and/or asphalt or adhesive application rate).

8.1.2 A copy of the published application instructions provided by the roof system assembly manufacturer.

8.1.3 A description of the test apparatus.

8.1.4 A record of all observations noted during each test during each pressure interval, including the final mode(s) of failure.

8.1.5 The pressure interval, and time within the interval, at which each test specimen failed.

8.1.6 The passing uplift pressure for each test specimen and the calculated average passing uplift pressure from the three tests. If additional tests are conducted to maintain the +15 percent criteria, record results from all additional testing.

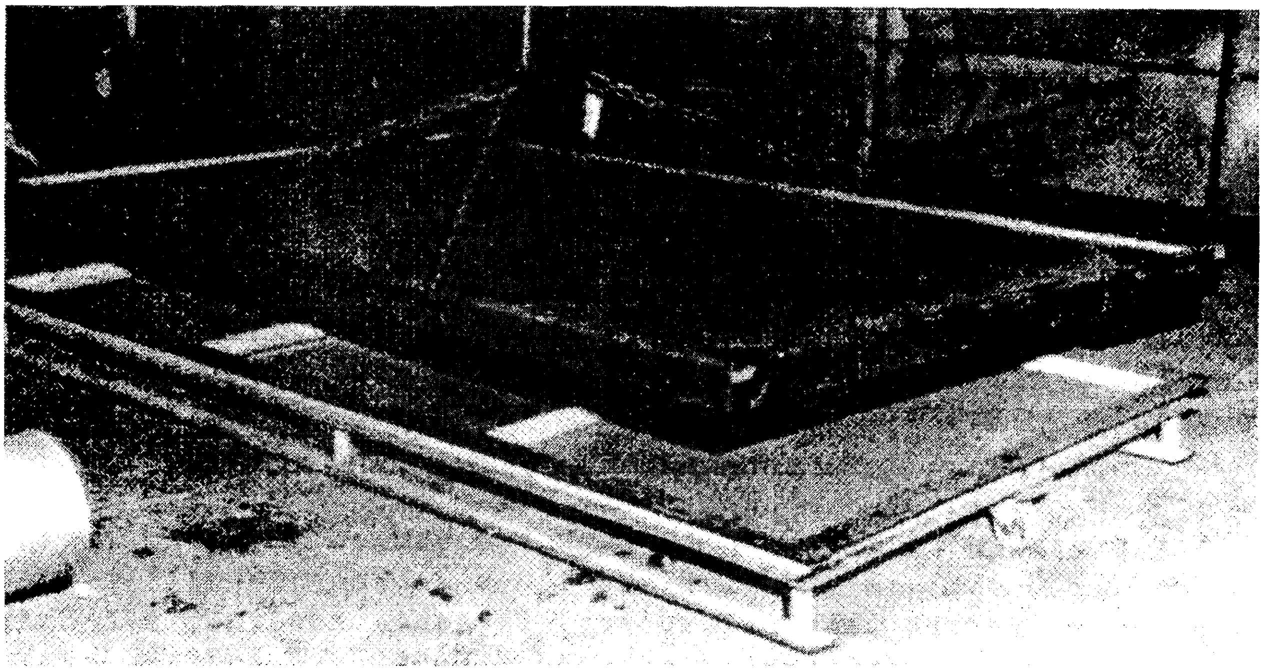


FIGURE C1
UPLIFT PRESSURE TEST APPARATUS

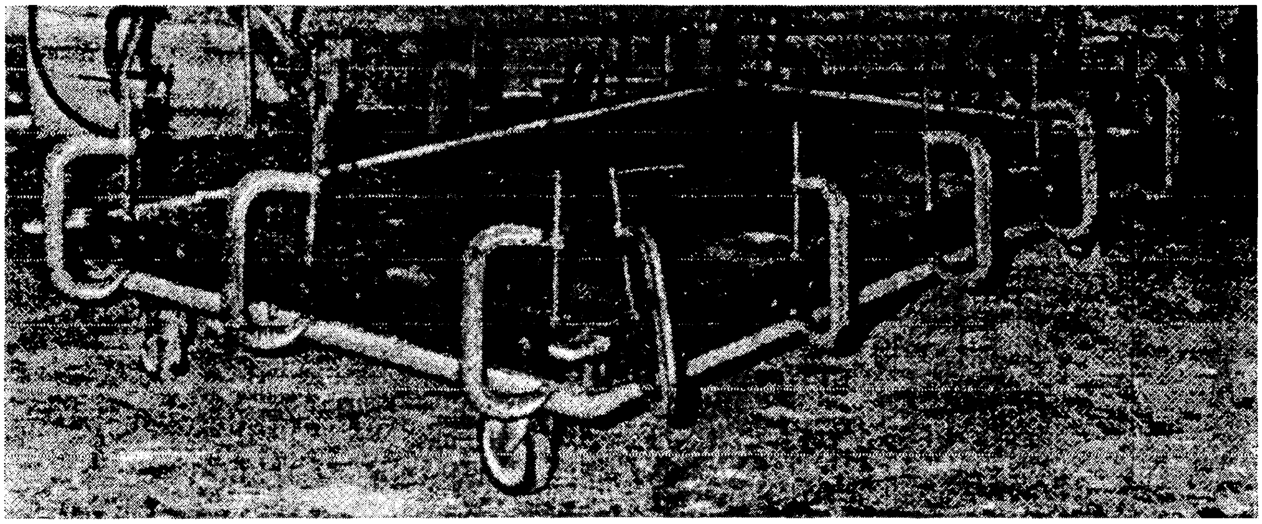


FIGURE C2
UPLIFT PRESSURE TEST SPECIMEN MOUNTED IN TEST

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX D

TEST PROCEDURE FOR SIMULATED UPLIFT PRESSURE RESISTANCE OF ADHERED ROOF SYSTEM ASSEMBLIES

1. Scope:

1.1 In situations where the uplift pressure test procedure described in Appendix B, C or J is not applicable, especially for liquid/spray applied roof constructions, the following test procedure may be used as an alternate method for evaluation of uplift resistance of the roof construction.

2. **Terminology**–the following definitions apply to the test procedure outlined herein.

2.1 Failure = roof system assembly failure under this test standard could be one or more of the following:

- tearing, splitting or other breakage of the roof cover;
- impairment of the waterproofing function of the roof systems assembly (i.e. cracking of components within the assembly);
- permanent deformation of the roof cover, which may reduce the waterproofing function of the roof system assembly over time; and,
- delamination or separation of adhered areas.

3. Apparatus:

3.1 The uplift pressure apparatus is a 2 foot by 2 foot by $1^1/_2$ inch (0.6 m by 0.6 m by 39 mm) plywood square containing a centrally located eyebolt secured to the top of the test panel. The plywood square is bonded to the top surface of the roof system assembly test specimen.

3.2 A load cell, or other force sensing device, is positioned in line and connected to the eyebolt. The opposite end of the load cell is attached to a chain-hoist assembly. Prior to testing, the load cell shall be calibrated such that the downward force incurred by the test apparatus mass is eliminated from recorded load values.

3.2 A minimum 2 inch (51 mm) wide strip is cut around and adjacent to the perimeter of the plywood down through the insulation to the deck.

4. Test Limitations and Precautions:

4.1 During the test, all testing agency representatives and other test observers shall wear ear and eye protection and hard hats to prevent injury.

4.2 This test procedure may involve hazardous materials, operations and equipment. This protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Test Specimens:

5.1 The components for a proposed test panel are assembled to the desired specifications and details (gauge of steel, application method and rate for the adhesives, size and thickness of insulation, type of cover) and then left to "cure" for a specified time period.

5.2 The test specimen shall be tested to 30 psf (1.4 kPa) after a 4 day laboratory cure time at ambient conditions. If the test specimen fails to resist this initial test pressure, the test shall be discontinued. On passing this initial testing, the test specimen shall be allowed to cure for the remaining cure time.

5.3 If insulation panels for part of the test specimen, a panels shall be installed such that a three way joint is located in the center of the test specimen. If more than one layer of insulation forms part of the test specimen, the top layer shall employ the three way joint.

5.4 Roof system assemblies whose wind-load resistance performance may be affected by bad weather conditions during installation shall be constructed in a manner which simulates actual working conditions.

6. Test Procedure:

6.1 Principal

6.1.1 The test apparatus is secured to the roof system assembly test specimen which is cut around the perimeter of the test apparatus. Thereafter, an uplift load is applied to the test apparatus which distributes the load over its area. The distributed load is transferred to the test specimen. Subsequent increasing uplift loads are applied until failure occurs.

6.2 Once the test specimen has cured and the test apparatus is secured, uplift loads are applied through the test apparatus in accordance with Table D1, below:

6.3 Prior to and during the attainment of the uplift pressures noted above, the test specimen is examined for failure. On failure, the test specimen is dismantled and examined to determine the exact mode of failure.

6.4 Record the mode, time, and pressure interval of failure.

7. Interpretation of Results:

7.1 The passing uplift pressure shall be the pressure which the test specimen resisted for one minute without failure.

7.2 The minimum passing uplift pressure for an approved roof system assembly shall be 90 psf (4.2 kPa).

7.3 A 2:1 margin of safety shall be applied to the passing uplift pressure prior to inclusion in the system manufacturer's Product Approval.

7.4 Average wind velocities can vary considerably from area to area. The *Florida Building Code, Building* utilizes a windspeed as noted in section 1620.2. These wind velocities in miles per hour are related to the design pressure, in pounds per square feet (kg/m^2), for a particular building. Refer to Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* and ASCE 7.

7.5 No extrapolation of resulting data will be accepted.

8. Report:

8.1 The final test report shall include the following:

8.1.1 A description of the roof system assembly test specimen, including the manufacturer of all components, a description of all components and the method of test specimen construction.

8.1.2 A copy of the published application instructions provided by the roof system assembly manufacturer.

8.1.3 A description of the test apparatus.

APPARATUS TABLE D1
UPLIFT LOAD INTERVALS AND CORRESPONDING PRESSURES

Time (Minute)	Load		Pressure	
	lbf	N	psf	kPa
0:01 to 1:00	120	534	30	1.4
1:01 to 2:00	180	801	45	2.2
2:01 to 3:00	240	1067	60	2.9
3:01 to 4:00	300	1334	75	3.6
4:01 to 5:00	360	1601	90	4.2
5:01 to 6:00	420	1868	105	4.9
6:01 to 7:00	480	2135	120	5.7
7:01 to 8:00	540	2402	135	6.5
8:01 to 9:00	600	2670	150	7.2

[1] Add 60 lbf (N) from each successive one minute interval.

8.1.4 A record of all observations noted during each pressure interval, including the final mode of failure.

8.1.5 The pressure interval, and time within the interval, at which the test specimen failed.

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX E

TEST PROCEDURE FOR CORROSION RESISTANCE OF FASTENERS, BATTEN BARS AND STRESS DISTRIBUTION PLATES

1. Scope:

1.1 The corrosion test procedure is designed to assess the potential damage to nails, metal fasteners, batten bars and stress distribution plates used for mechanically attached roof covers and/or attachment of insulation. There is no single test procedure that approximates all climactic conditions experienced by roofing components; however, tests are available that provide an indication of potential resistance to corrosion.

1.2 All nails and carbon steel fasteners shall be tested for corrosion resistance in compliance with ASTM Standard Practice G 85 [(Modified Salt Spray (Fog) Testing)], Annex A5 (Dolute Electrolyte Cyclic Fog/Dry Testing) as modified for the *Florida Building Code, Building* and noted in Section 2, herein.

1.3 All batten bars, stress distribution plates, and other metal fastener types shall be tested for corrosion resistance in compliance with DIN 50018 as noted in Section 3, herein.

2. ASTM G 85–All nails and carbon steel fasteners shall be tested for corrosion resistance in compliance with ASTM Standard Practice G 85 except as noted below.

2.1 Salt solution:

2.1.1 The salt solution shall consist of an electrolyte solution of 0.05 percent sodium chloride and 0.35 percent ammonium sulfate by mass.

2.1.2 The water and sodium chloride shall meet the purity requirements of Section 6 of ASTM G 85. The ammonium sulfate shall contain not more than 0.3 percent total impurities.

2.2 Conditions in the salt fog chamber:

2.2.1 One cycle shall consist of 1 hour fog followed by 1 hour dry-off.

2.2.2 During the fog period, the chamber shall be at ambient room conditions [(i.e. 75 + 6°F (24 + 3°C)].

2.2.3 During the dry-off period, the temperature throughout the exposure zone shall reach and remain at 95 + 3°F (35 + 1.5°F) within $^{3}/_{4}$ hour of switching from the fog period to the dry period.

2.2.3.1 The dry-off shall be achieved by purging the chamber with fresh air, such that within $^{3}/_{4}$ hour all visible moisture is dried off the specimens.

2.2.3 The pH of the collected solution shall range between 5.0 and 5.4, as measured in compliance with ASTM E 70.

2.3 Saturation Tower:

2.3.1 This test does not use humidified air; therefore, one of the following methods shall be utilized to avoid humidifying the air.

- Empty the saturation tower and ensure that the tower heaters are tuned off; or,
- Arrange the spray plumbing so that the atomizing air does not go through the saturation tower, but goes directly to the spray nozzle.

2.4 Atomization and quantity of fog:

2.4.1 Collect the fog in a special continuous spray run of at least 16 hours, performed between test runs. The regular spray periods of 1 hour are not long enough for collecting sufficient fog to make accurate determinations of deposition rate. See Section 4.3.2 of ASTM G 85 for instructions on fog collection.

2.5 Cabinet modification:

2.5.1 In order to achieve the temperature changes for this test, modifications or additions to the ASTM Test Standard B 117 apparatus may be required. These may include modifications to:

- exposure chamber;
- temperature controls;
- air flow apparatus;
- insulation; and,
- means for conditioning the heated air in the chamber or water in the jacket.

2.5.2 Two manufacturers of cabinets which meet the needs of this test are:

- Arotech—Cleveland, Ohio
- Q Panel—Cleveland, Ohio

2.5.3 Consult the cabinet manufacturer for any additional information or suggestions for cabinet modification to meet the needs of this test.

2.6 Period of time:

2.6.1 The acetic acid-salt spray (fog) test shall be conducted for 140 cycles for nails and 180 cycles for carbon steel fasteners, where one cycle consists of 1 hour fog and 1 hour dry-off. Continuous operation implies that the chamber be closed except for the short daily interruptions necessary to inspect, rearrange, or remove test specimens, and to check and replenish the solution in the reservoir. Schedule operations so that these interruptions are held to a minimum.

2.6.1.1 Any test specimen which exhibits corrosion on an area in excess of 5 percent of its total surface area shall be considered as failing the corrosion resistance test. It shall be the responsibility of the testing agency representative to conduct an objective visual examination of the test specimen regarding its percentage of corroded or rusted area.

2.6.2 As an alternate, the test specimen may be tested along side a ‘control’ specimen consisting of ‘wire,’ of similar type and diameter as the test specimen, which is zinc-coated (galvanized), in compliance with ASTM A 641, to a zinc-coating weight of not less than 0.28 ounces per square feet (0.00073 kg/m^2), as measured in compliance with ASTM A 90.

2.6.2.1 The test specimen and control specimen (noted in Section 2.4.2) shall be tested concurrently until:

- The test specimen exhibits visually notable signs of corrosion while the control specimen does not;
- The control specimen exhibits visually notable signs of corrosion while the test specimen does not; or,
- If the test and control specimens exhibit equivalent signs of corrosion during the test, the test shall continue for 140 continuous cycles.

2.6.2.2 Any test specimen which exhibits visually notable signs of corrosion prior to the control specimen shall be considered as failing the corrosion resistance test. It shall be the responsibility of the testing agency representative to conduct an objective visual examination of the test and control specimens regarding corrosion or rusting.

2.6.2.3 If it becomes necessary to test for the full 140 cycles, the criteria shall be as noted in Section 2.6.1.1.

2.6.3 The cabinet manufacturer Q Panel (Cleveland, Ohio), noted above, also provides metal wire samples of various diameters which are coated and measured in compliance with Section 2.6.2 and can be used as control specimens.

3. **DIN 50018**–All batten bars, stress distribution plates, and other fastener types shall be tested for corrosion resistance in compliance with DIN 50018.

3.1 Duplicate tests are conducted in accordance with the DIN 50018 Standard Kesternick Test (2.01) on samples prepared first with fasteners (other than nails) installed in: 1) minimum 22 gage steel deck; 2) minimum 3000 pounds per square inch (20 685 kPa) concrete; or, 3) minimum $^3/_4$ inch thick plywood (where applicable).

3.2 For concrete and plywood samples, the fasteners are removed from the substrate before testing. Each sample is subjected to 15 cycles of exposure. Batten bars and plates shall also meet these requirements.

3.3 Evaluation of DIN 50018 results:

3.3.1 The fastener, stress distribution plate and/or batten bar shall not show more than 15 percent of the surface area rusted. Coatings covering these components shall not blister, peel or crack. It shall be the responsibility of the testing agency representative to conduct an objective visual examination of the test specimen regarding its percentage of corroded or rusted area and/or the degradation of any coatings.

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX F

TEST PROCEDURE FOR SUSCEPTIBILITY TO HAIL DAMAGE FOR ROOF SYSTEM ASSEMBLIES

1. Scope:

1.1 Simulated hail damage test procedures are designed to assess the potential for damage to roof system assemblies when adhered directly to insulation, lightweight concrete roof decks, structural concrete roof decks, gypsum decks or fire-treated wood roof decks. The procedures were developed to determine the potential for puncture of the roof cover resulting from hail storms when the roof cover is applied over its tested substrate within an approved assembly.

1.2 Due to the variable severity of potential damage resulting from hail storms in different geographic areas, two separate hail damage tests are used. The tests yield ratings identified as Class 'SH' (Severe Hail Damage Resistant) and Class 'MH' (Moderate Hail Damage Resistant).

2. Description of Test Apparatus:

2.1 *Class 'SH'*—The test apparatus consists of a plastic tube 2 inches (51 mm) inside diameter, supported above the sample. A steel ball $1^3/_4$ inch (45 mm) in diameter, weighing 0.79 pounds (3.5 N) is dropped from a height of 17 feet $9^1/_2$ inches (5.4 m) onto the sample. This procedure is repeated 10 times on various sections of the sample. This procedure generates an impact energy of approximately 14 pounds per feet (19 J) over the impact area of a $1^3/_4$ inch (45 mm) diameter ball.

2.2 *Class 'MH'*-The test apparatus consists of a steel tube $2^1/_4$ inches (57 mm) inside diameter supported vertically above the sample by a tripod. Holes are drilled in the steel tube to allow the release mechanism to be adjusted for the proper drop height. A steel ball 2 inches (51 mm) in diameter, weighing 1.625 pounds (737 g) is dropped from a height of 5 feet (1.5 m) through the tube onto the sample. This procedure is repeated 10 times on various sections of the sample. This procedure generates an energy of approximately 8 pounds per feet (10.8 J) over the impact area of a 2 inch (51 mm) diameter ball.

3. Test Procedure:

3.1 Two identical roof cover samples, 2 feet by 4 feet (0.6 m by 1.2 m) are selected from the material to be tested. The first sample is prepared with the roof cover applied to the selected insulation substrate(s) or adhered directly to the appropriate roof deck in accordance with the manufacturer's specifications. After preparation, the sample is conditioned for up to 28 days (laboratory cure). For materials supplied as sheets or rolls, the sample shall incorporate a field seam within the assembly, in the center and running parallel to the 4 foot (1.2 m) side. The second sample is loose laid over the matching substrate or roof deck. Both samples are subjected to initial testing. The $1^3/_4$ inch (45 mm) diameter steel ball is dropped onto the sample from a height of 17 feet $9^1/_2$ inches (5.4 m) for a Class 'SH' rating, or the 2 inch (51 mm) diameter ball is dropped onto the sample from a height of 5 feet (1.5 m) for a Class 'MH' rating. A minimum of ten drops of the impactor is required, five of which shall be on the field-fabricated seam, if appropriate. The samples are then removed and inspected for damage.

3.2 A piece of loose laid sample 12 inch by 24 inch (305 mm by 610 mm) is cut from the original sample, and then further conditioned (weathered) for 1000 hours in a fluorescent ultraviolet condensation-type weathering apparatus using the ASTM G 53 Test Method. After weathering, the impact test procedure is repeated. The sample is then removed and inspected for damage.

4. Evaluation of Results:

4.1 The roof cover shall not show any signs of cracking or splitting. The field seam shall not show any signs of cracking, splitting, or separation or rupture when examined closely under a 10x magnification. The cover thickness shall be checked at the points of impact.

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX G

TEST PROCEDURE FOR SUSCEPTIBILITY TO LEAKAGE FOR ROOF SYSTEM ASSEMBLIES

1. Scope:

1.1 The Susceptibility to Leakage Test Procedure is designed to assess the potential for water migration when the cover is fabricated with a typical lap seam or perimeter detail.

2. Description of Test Apparatus

2.1 The test apparatus consists of top and bottom sections that are bolted together with the specimen being evaluated placed as a diaphragm between the sections. The top section consists of a $9^1/_4$ inch (203 mm) diameter cap which has two $^1/_2$ inch (13 mm) diameter threaded inlet holes. This top cap is cemented to a $5^3/_4$ inch (146 mm) length of $7^3/_4$ inch (1197 mm) diameter clear acrylic pipe which is cemented to an $11^5/_8$ inch (295 mm) diameter pipe flange. The bottom section consists of a $9^1/_4$ inch (235 mm) cap which has two $^1/_2$ inch (13 mm) diameter threaded inlet holes. The bottom cap is cemented to a $5^7/_8$ inch (149 mm) length of $7^3/_4$ inch (197 mm) diameter clear acrylic pipe which is cemented to an $11^5/_8$ inch (295 mm) diameter pipe flange.

2.2 Both top and bottom sections are bolted together at the flanges with the cover being evaluated between them. The top and bottom caps are fabricated to allow a standing head of water above and additional air pressure above and below. Each section is fabricated with two $^1/_2$ inch (13 mm) diameter pipe outlets to allow connection of an air pressure inlet and pressure gauge.

3. Test Procedure:

3.1 An 18 inch (457 mm) diameter sample is prepared with the roof cover. This specimen is prepared with a field seam and/or penetration detail included and running along the diameter of the sample. The completed sample is conditioned (weathered) for 288 hours (minimum) in an Ultraviolet Weatherometer before being cut to a 10 inch (254 mm) diameter size.

3.2 The 10 inch (254 mm) diameter specimen is then bolted in place between the flanges of the test apparatus. Water is then placed over the sample to a depth of 6 inches (152 mm) and maintained for a period of 7 days. At the end of the 7 day period, air is introduced below the water to a 1 pound per square inch (6.8 kPa) level and cycled 25 times from 1 pounds per square inch (6.8 kPa) level and cycled 25 times from 1 pounds per square inch (6.8 kPa) to ambient.

4. Evaluation of Results:

4.1 There shall be no signs of water leakage during the 7 day period. In addition, there shall be no signs of water leakage during or after the pressure cycles.

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX H

TEST PROCEDURES FOR SMALL SCALE QC AND PHYSICAL PROPERTIES OF APPROVED ROOF SYSTEM ASSEMBLIES

1. Scope:

1.1 The following series of small scale tests are designed to allow monitoring of quality controls exercised in the manufacture of single-ply roof covers and/or to characterize individual materials. In addition, they may be used to assess certain physical characteristics necessary for the continued performance of a cover assembly when installed within a construction. It may not be appropriate to require all tests for each construction. A preliminary decision shall be made as to which tests will be required. The decision will be based on several factors: e.g., (a) from what basic material or polymer is the roof membrane fabricated; (b) how is the roof membrane applied; (c) how is the roof membrane secured; (d) to what substrates is the roof membrane applied, etc.

2. Delamination Test:

2.1 The roof membrane is applied to the top surface of an insulation sample in accordance with the manufacturer's specifications and allowed to cure for the specified period of time, maximum 28 days. This assembly is then cut into 6 inch by 6 inch (152 mm by 152 mm) pieces prior to assembly of the test specimen. Plywood, 6 inch by 6 inch by $^3/_4$ inch (152 mm by 152 mm by 19 mmm), is adhered to the top and bottom surface of the prefabricated specimen with a compatible adhesive. A steel plate, 6 inch by 6 inch by $^1/_2$ inch thick (152 mm by 152 mm by 13 mm), is fastened to the plywood facers with four #12, $1^1/_4$ inch diameter by 6 inch (152 mm) long bolts on each plate. Force is exerted in a direct line parallel to the shank of the bolt at a constant machine speed of 2 inch (51 mm) per minute. A minimum of three tests must be conducted on each selected substrate. The ultimate average load of failure is then determined.

3. Peel Test (ASTM D 1781):

3.1 The roof membrane is applied to the top surface of an insulation sample in accordance with the manufacturer's specifications such that a minimum 1 inch (25 mm) extends beyond the edge of the rigid insulation after cutting and trimming. The top 3 inches (76 mm) of the cover is not adhered to the insulation substrate. The sample is allowed to cure for the specified time, maximum 28 days. The assembly is cut into 3 inch (76 mm) by 12 inch (305 mm) pieces with the 1 inch (25 mm) excess cover at each 3 inch (76 mm) end. The top edge is held with a suitable clamp and the bottom edge is clamped to the peel drum tester.

3.2 The specimen and test apparatus are then suspended from the top head of the testing machine. A peel of at least 6 inches (152 mm) of the cover is then made with the machine speed set at 1 inch (25 mm) per minute. A minimum of 3 tests shall be conducted on each selected substrate. The average peeling load required to peel the facing is then calculated in pound per inch of peel torque.

4. Tensile Test (ASTM D 1781):

4.1 ASTM D 638 — The roof cover is cut according to ASTM D 638 Type IV. The specimen is clamped into the upper and lower jaws of the tensile testing machine, with the machine speed set at 20 inches per minute (8.5 mm/s). Determination of stress is conducted at 100 percent, 200 percent, and 300 percent elongation as well as ultimate failure (if possible). A minimum of 3 tests shall be conducted.

4.2 ASTM D 751 — The roof cover is fabricated with a field seam according to the manufacturer's specifications before being cut according to ASTM D 751 seam strength determination instructions. The specimen is clamped into the upper and lower jaws of the tensile testing machine, with the machine speed set at 12 inch per minute (5 mm/s). Determination of stress is conducted at 100 percent, 200 percent, and 300 percent elongation, as well as at ultimate failure (if possible). A minimum of 3 tests shall be conducted.

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX I

TEST PROCEDURE FOR STATIC AND DYNAMIC PUNCTURE RESISTANCE OF ROOF SYSTEM ASSEMBLIES

1. Scope:

1.1 The test procedures outlined herein cover the maximum static and dynamic puncture loads which roofing membrane samples can withstand without allowing the passage of water due to puncture. Membrane samples are subjected to both static and dynamic puncture loads from a rigid object having a sharp edge to determine their puncture resistance performance.

1.2 This laboratory test is conducted at any desired temperature using sheet membrane samples manufactured in a factory or prepared in a laboratory.

1.3 Roof membrane samples to which the method is applicable include bituminous built-up, polymer-modified bitumen, vulcanized rubber, non-vulcanized polymeric, and thermoplastic materials. The method is not applicable to aggregate-surfaced membrane samples.

2. Terminology:

2.1 *Definitions*—For definitions of terms, refer to ASTM D 1079 or Chapter 2 and Section 1513 of the *Florida Building Code, Building*. The definitions from the *Florida Building Code, Building* shall take precedence.

3. Significance and Use:

3.1 An important factor affecting the performance of membrane roof system assembly is their ability to resist static and/or dynamic puncture loads. The test procedures outlined herein provide a means to assess static and dynamic puncture resistance.

3.2 The methods can be used to compare the puncture resistance of a single type of membrane sample as a function of a variety of insulation substrates or, conversely, to compare the resistance of a number of membrane samples set on a single type of insulation.

3.3 The effect of temperature on puncture resistance can be studied by conducting the test under controlled conditions using such equipment as an environmental chamber, oven, or freezer.

3.4 The methods can be useful in developing puncture resistance performance criteria and/or classifications for membrane roof system assemblies.

4. Apparatus:

4.1 Static puncture test

4.1.1 The static puncture test apparatus shall consist primarily of a movable rod to which a $^3/_8$ inch (10 mm) diameter ball bearing is attached at one end and a means for loading the specimen is attached to the other. The static puncture test apparatus is shown in Figure I1, herein.

4.1.2 One means for static puncture loading is to attach to the movable rod a platform on which deadweights are placed. Alternatively, pneumatic loading may be used whereby the ball bearing is attached to the movable rod and the load is measured by an air pressure gauge which has been calibrated against a load cell.

4.1.3 The length of the rod above the specimen shall be not less than 3.9 inch (100 mm). A framework, having a minimum width of 9.8 inches (250 mm), supports the rod perpendicular to the surface of the test specimen. Free vertical movement of the rod shall not be hindered by the framework. The rod and framework shall be capable of supporting loads up to 56 lbf (250 N).

4.2 Dynamic puncture test:

4.2.1 The dynamic puncture test apparatus shall consist primarily of a heavy base, a falling arm and a puncture head. The dynamic puncture test apparatus is shown in Figure I2, herein.

4.2.2 The falling arm shall be attached to the base such that it can rotate freely (e.g. using ball bearings) from a vertical to a horizontal position. The length of the arm shall be 1.7 feet (0.51 m).

4.2.3 The shape and dimensions of the puncture head are shown in Figure I3, herein Several heads of differing mass may be needed. Alternatively, a means of adding mass to a given puncture head may be utilized. The puncture head and additional masses shall constitute a continuous series of mass from 2.2 to 22.0 pounds (1 to 10 kg) in 1.1 pounds (0.5 kg) increments. The mass of the puncture head for any given test shall be within + 5 percent of that selected.

4.2.4 When mounted on the rotating arm, the face of the puncture head shall be parallel to the arm's axis of rotation. When the puncture head contacts the membrane surface, the rotating arm shall be horizontal.

4.2.5 The apparatus shall incorporate a mechanism which allows the puncture head to remain stationary when in an upright position, forming an angle with the vertical of not greater than 5 degrees. The mechanism shall allow for release of the arm such that is falls freely from gravitational forces only. A vacuum release mechanism has been found suitable for this purpose.

4.2.6 The apparatus base, on which the rotating arm and puncture head are mounted, shall be placed on a horizontal surface such that no movement occurs when the test is conducted at maximum impact energy.

4.2.7 The membrane test specimen shall be held in place over the substrate with a square frame having minimum exterior and interior dimensions of 9.8 inches (250 mm) and 7.9 inches (200 mm), respectively.

5. Test Limitations and Precautions:

5.1 This test procedure may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

6. Test Specimens:

6.1 Sampling–single-ply specimens:

6.1.1 Test specimens shall be cut directly from the sheet membrane and insulation materials provided for the test using a metal template having dimensions of 7.9 inches by 7.9 inches (200 mm by 200 mm), ± 5 percent.

6.2 Sampling–multi-ply specimens:

6.2.1 Test samples, having dimensions not less than 3 feet by 4 feet (0.9 m by 1.2 m), shall be prepared in compliance with the roof system assembly manufacturer's published installation instructions and details. The quantity of materials in each layer shall be within + 10 percent of that specified in the published installation instructions.

6.2.2 All roofing components to be used in the roof system assembly test specimen shall be conditioned at 77°F + 3°F (25°C + 2°C) and 50 percent + 5 percent relative humidity for a 24 hour period prior to test sample construction.

6.2.3 Test specimens shall be cut directly from the constructed 3 feet by 4 feet (0.9 m x 1.2 m) test sample as noted in Section 6.1.1, herein.

6.3 A minimum of 4 test specimens shall be constructed and tested.

6.4 Unless otherwise specified, the membrane substrate shall be expanded polystyrene board having a density within the range of 1.7 to 2.0 lbm/ft^3 (27 to 32 kg/m^3) and a thickness of 1.5 inch (38 mm), + 15 percent.

7. Conditioning:

7.1 The test apparatus and test specimen shall be conditioned at the desired temperature for a minimum of 8 hours prior to testing. The selected temperature shall be maintained at + 3°F (+ 2°C) for the duration conditioning.

8. Test Principal:

8.1 Static puncture:

8.1.1 The roof system assembly test specimen is subjected to a predetermined static puncture load using a ball bearing for a period of 24 hours. The puncture loads are increased in 2.2 lbf (10 N) increments until puncture of the test specimen occurs or until the maximum load of 56 lbf (250 N) is reached. Puncture of the test specimen is assessed by visual examination and verified by conducting a watertightness pressure test.

8.2 Dynamic puncture:

8.2.1 The Roof System Assembly test specimen is subjected to a predetermined dynamic puncture load created by a rigid puncture head falling through a 90 degree trajectory from a vertical position to a horizontal position under gravitational acceleration. The impact energy is increased from 119 foot-pdl (5 J) in 59.4 foot-pdl (2.5 J) increments until puncture of the test specimen occurs or until the maximum impact energy of 1190 foot-pdl (50 J) is reached. Puncture of the test specimen is assessed by visual examination and verified by conducting a watertightness pressure test.

8.2.2 The impact energy is equated to the potential energy of the raised puncture head, as noted below.

$E = m x g x h$ where,

E = impact energy (ft-pdl or J);

m = puncture head mass (lbm or kg);

g = gravitational acceleration (32.2 ft/s^2 or 9.8 m/s^2):

h = the puncture head fall distance (1.7 ft or 0.51 m).

9. Test Procedures:

9.1 Static puncture:

9.1.1 Place a test specimen on an insulation substrate and position the assembly within the framework of the test apparatus such that the ball bearing is set on the center of the surface of the specimen. Assure that the movable rod is aligned perpendicular to the specimen surface.

9.1.2 Select a static puncture load, in an increment of 2.2 lbf (10 N), somewhat below that at which the specimen may be expected to fail.

Notes:

1. Pretesting specimens under various loads is useful to estimate the initial load to be applied.
2. If a platform and deadweights are used as the means to provide loading of the specimen, then the mass of the ball bearing, rod, and platform assembly must be included in the load applied to the specimen.

9.1.3 Apply the initial static puncture load to the test specimen for 24 hours. Then remove the specimen from the test apparatus and visually examine it to determine whether puncture has occurred.

9.1.4 If test specimen puncture cannot be determined through visual examination, a suitable watertightness test, using a water pressure of 0.73 lbf/in^2 (5000 Pa) applied to the surface of the membrane, shall be conducted for 15 minutes.

Note: One type of watertightness test that has been used to examine whether membrane specimens have been punctured incorporates a water column sealed to the top of the membrane specimen. A water height of 20 inches (500 mm) provides a pressure of 0.73 lbf/in^2 (5000 Pa). Alternatively, a chamber in which the membrane specimen is sealed and into which water is forced at the specified pressure may be utilized.

9.1.5 If the test specimen punctures or is not watertight due to the initial static puncture load, repeat Sections 9.1.1 through 9.1.4 on another test specimen using a lesser initial load. If no puncture is seen or if the test specimen is determined to be watertight after the initial loading, continue the test as noted in Section 9.1.6.

9.1.6 Increase the applied static load by 2.2 lbf (10 N) on the same specimen and maintain this for 24 hours. Determine whether membrane puncture has occurred, either through visual examination or through watertightness testing. Continue increasing the applied static load on the same specimen in increments of 2.2 lbf (10 N), maintaining each load for 24 hours, until puncture occurs or until the maximum load of 56 lbf (250 N) is reached. Record the load at which puncture occurs or a maximum load of 56 lbf (250 N) if no puncture occurs.

9.1.7 Conduct the test on three additional test specimens according to Section 9.1.6 using a initial load that is 2.2 lbf (10 N) less than that which caused puncture in the first set of tests or using an initial load of 56 lbf (250 N) if the first set of tests yielded no puncture. Consider the results as follows:

9.1.7.1 If none of the three specimens are punctured at this selected load, report that load as the puncture resistance of the test specimen. A watertightness test shall be conducted on all three test specimens to verify that puncture did not occur.

9.1.7.2 If puncture occurs on any of the three test specimens, repeat Section 9.1.6 using an initial load that is 2.2 lbf (10 N) less than that which caused puncture. Repeat until no puncture is observed in all three test specimens as noted in Section 9.1.7.1.

9.2 Dynamic puncture:

9.2.1 Place a test specimen on an insulation substrate and position the assembly within the horizontal framework of the test apparatus such that the puncture head will strike the center of the test specimen.

9.2.2 Select an initial mass of the puncture head, in an increment of 1.1 pounds (0.5 kg), somewhat below that at which the specimen may be expected to fail.

Notes: 1. Pretesting specimens under various loads is useful to estimate the initial puncture head mass to be used.

9.2.3 Position the rotation arm, with the selected puncture head, in the vertical position and allow the arm to drop under gravitational acceleration. Then remove the specimen from the test apparatus and visually examine it to determine whether puncture has occurred.

9.2.4 If test specimen puncture cannot be determined through visual examination, a suitable watertightness test, using a water pressure of 0.73 lbf/in^2 (5000 Pa) applied to the surface of the membrane, shall be conducted for 15 minutes.

Note: One type of watertightness test that has been used to examine whether membrane specimens have been punctured incorporates a water column sealed to the top of the membrane specimen. A water height of 20 inches (500 mm) provides a pressure of 0.73 lbf/in^2 (5000 Pa). Alternatively, a chamber in which the membrane specimen is sealed and into which water is forced at the specified pressure may be utilized.

9.2.5 If the test specimen punctures or is not watertight due to the initial dynamic puncture load, repeat Sections 9.2.1 through 9.2.4 on another test specimen using a lesser initial load. If no puncture is seen or if the test specimen is determined to be watertight after the initial loading, continue the test as noted in Section 9.2.6.

9.2.6 Increase the mass of the puncture head by 1.1 pounds (0.5 kg) and conduct the test on the same specimen. Determine whether membrane puncture has occurred, either through visual examination or through watertightness testing. Continue increasing the mass of the puncture head in increments of 1.1 pounds (0.5 kg) and conduct the test on the same specimen until puncture occurs or until the maximum puncture head mass of 22 pounds (10 kg) has been used. Record the puncture head mass at which puncture occurs or a maximum puncture head mass of 22 pounds (10 kg) if no puncture occurs.

9.2.7 Conduct the test on three additional test specimens according to Section 9.2.6 using an initial puncture head mass that is 1.1 pounds (0.5 kg) less than that which caused puncture in the first set of tests or using an initial puncture head mass of 22 pounds (10 kg) if the first set of tests yielded no puncture. Consider the results as follows:

9.2.7.1 If none of the three specimens are punctured at this puncture head mass, calculate the energy in compliance with Section 8.2.2 and report that energy as the dynamic puncture resistance. A watertightness test shall be conducted on all three test specimens to verify that puncture did not occur.

9.2.7.2 If two of the three specimens are not punctured, test one additional specimen using the same puncture head mass as used in Section 9.2.7. If this additional test specimen is not punctured, calculate the energy in compliance with Section 8.2.2 and report that energy as the dynamic puncture resistance. If the additional test specimen is punctured, repeat Section 9.2.7 using three new test specimens and a puncture head mass which is 1.1 pounds (0.5 kg) less than that which caused puncture in the additional specimen.

9.2.7.3 If two of the three specimens are punctured, repeat Section 9.2.7 using three new test specimens and a puncture head mass which is 1.1 pounds (0.5 kg) less than that which caused puncture in two of the three specimens. Consider the results as noted in Sections 9.2.7.1 through 9.2.7.3.

10. Report:

10.1 The report of test shall include the following:

10.1.1 Complete identification of the test specimen including types, sources, manufacturers, dimensions, etc. of all components in the specimen and the method of preparation.

10.1.2 The temperature of the test.

10.1.3 A description of the watertightness test used.

10.1.4 The static puncture resistance of the specimen as the load which three specimens can support for 24 hours without puncture and without loss of watertightness.

10.1.5 The dynamic puncture resistance of the membrane material as the maximum impact energy which three specimens sustained without puncture and without loss of watertightness. The direct of the specimen shall be included.

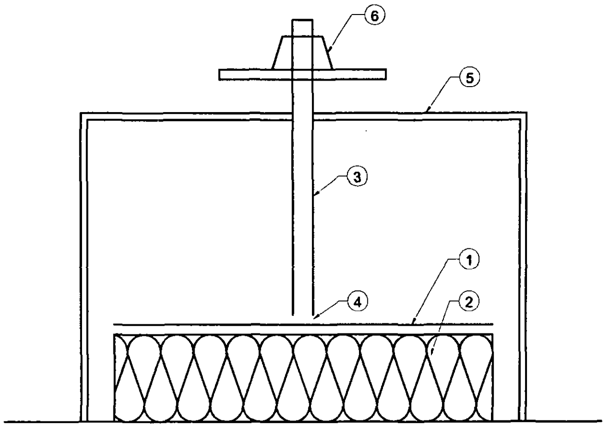
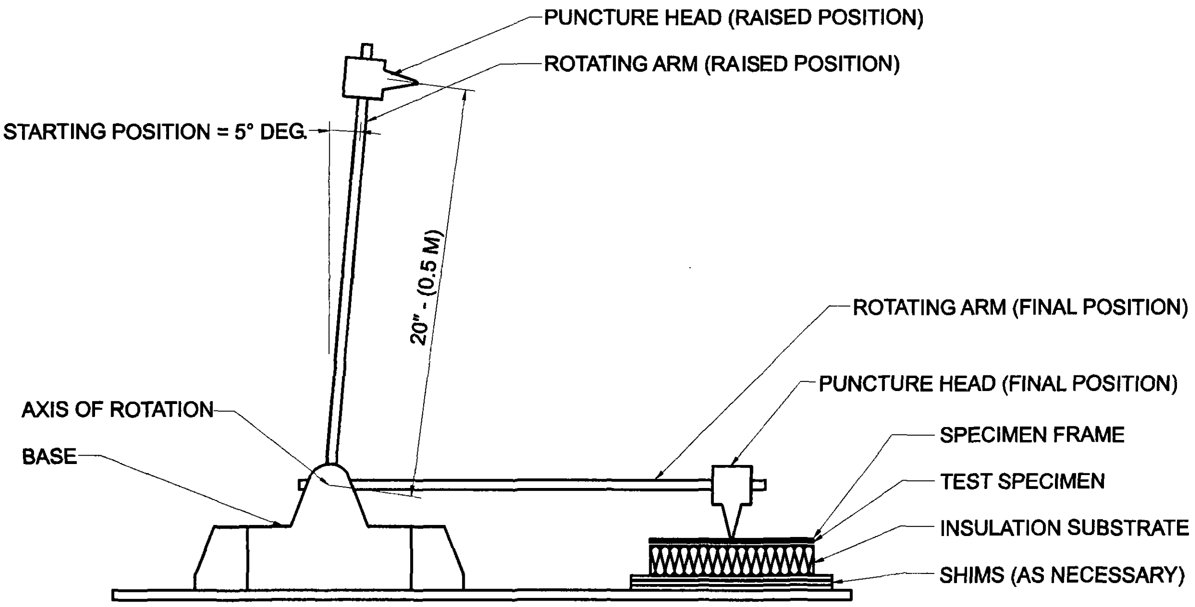


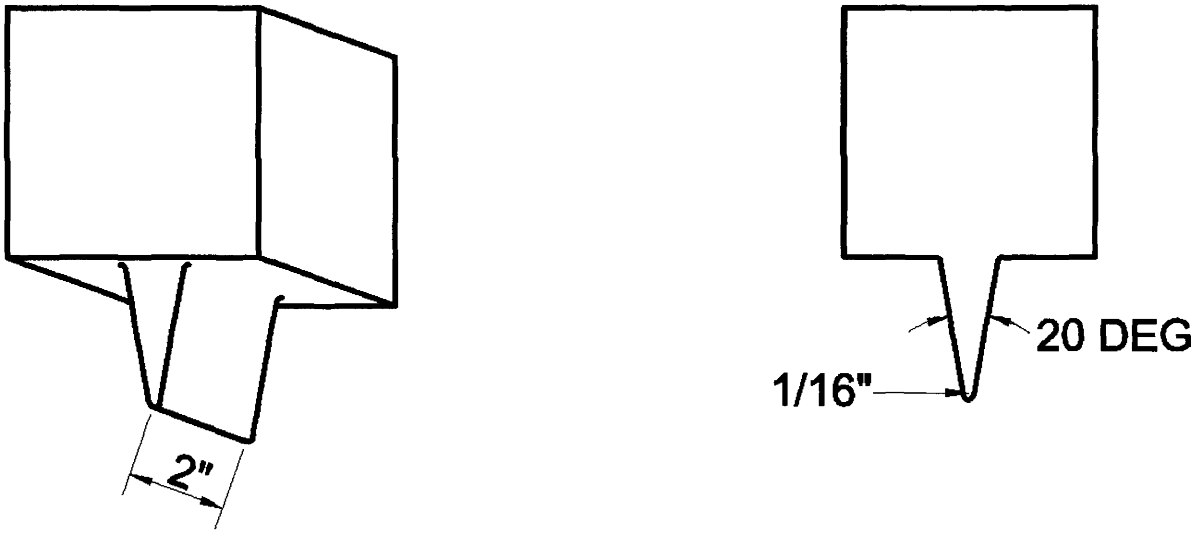
FIGURE I1
STATIC PUNCTURE TEST APPARATUS

1. **Membrane test specimen**
2. **Insulation substrate**
3. **Movable rod**
4. **Ball bearing**
5. **Framework supporting movable rod and load**
6. **Applied load**


PUNCTURE HEAD (RAISED POSITION)
ROTATING ARM (RAISED POSITION)
STARTING POSITION = 5° DEG.
20" - (0.5 M)
ROTATING ARM (FINAL POSITION)
PUNCTURE HEAD (FINAL POSITION)
AXIS OF ROTATION
BASE
SPECIMEN FRAME
TEST SPECIMEN
INSULATION SUBSTRATE
SHIMS (AS NECESSARY)

For SI: 1 inch = 25.4 mm.

FIGURE I2
DYNAMIC PUNCTURE TEST APPARATUS



For SI: 1 inch = 25.4 mm.

FIGURE I3
TYPICAL DYNAMIC PUNCTURE HEAD

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX J

TEST PROCEDURE FOR 12 FOOT BY 24 FOOT SIMULATED UPLIFT PRESSURE RESISTANCE OF ROOF SYSTEM ASSEMBLIES

1. Scope:

1.1 Damage incurred by the effects of wind over and internal pressure under a totally adhered, partially adhered or mechanically attached Roof System Assembly generally results in one or more of the following:

- Uplift of the cover (when totally adhered);
- Delamination within the roof insulation cover (when totally or partially adhered);
- Failure of adhesive between the insulation and the deck or between the insulation and the vapor retarder and/or between the vapor retarder and the deck; and,
- Failure of the fastener/substrate, fastener/insulation or fastener/roof cover combination.

1.2 Thus the nature of the damage incurred would suggest that an instrument designed to measure the stability of roof assemblies be equipped to evaluate bond strength indicated in the items above. The 12 foot by 24 foot simulated uplift pressure test has been designed for this purpose.

1.3 The object of the test is to provide a realistic method of evaluating the uplift resistance of a completed roof construction and its individual components when applied within a completed assembly. The test procedure must contain the ability to realistically evaluate the actual size of the roof components which comprise a completed roof system assembly.

1.4 The test method is applicable to any roof system assembly incorporating the deck, air/vapor retarders, insulation, roof cover, adhesives, sealants, mechanical fasteners, batten bars and proprietary fastening systems.

1.5 The test method is designed to measure the stability of the Roof System Assembly on its supports and to evaluate the ultimate strength of the individual components in the completed Roof System Assembly under static conditions which are intended to simulate the uplift loads imposed by wind forces on the roof system. The roof specimen is sufficiently large so that the means of securing the perimeter of the sample to the pressure vessel have virtually no effect on the ultimate behavior of the assembly during testing.

1.6 The test procedure described in Appendix C does not adequately evaluate the performance of some newer roof constructions. With the increased use of extended fastener spacings in mechanically attached single-ply cover construction and air/vapor retarders, the perimeter edge effect of small or intermediate scale tests produces unreliable results. Therefore, a larger sample size is needed to properly evaluate resistance to wind uplift forces.

2. **Terminology**–the following definitions apply to the test procedure outlined herein.

2.1 Failure–Roof system assembly failure under this test standard could be one or more of the following:

- withdrawal or breakage of fasteners;
- tearing, splitting or other breakage of the roof cover at the point(s) of attachment;
- impairment of the waterproofing function of the roof systems assembly (i.e. cracking of components within the assembly);
- permanent deformation of the roof cover or fastener assembly, including stress plate, which may reduce the waterproofing function of the roof system assembly over time; and,
- delamination or separation of adhered areas.

3. Apparatus:

3.1 The 12 foot by 24 foot uplift pressure apparatus is a steel pressure vessel arranged to supply air pressure at pre-established pressure levels to the underside of the roof system assembly. This roof system assembly, when secured in place, forms and seals the top of the pressure vessel.

3.2 The pressure vessel measures 24 feet-7 inch long by 12 feet-7 inch wide by 2 inch deep (7.5 m by 3.8 m by 51 mm). It is fabricated from 8 inch (203 mm) deep steel channel sections as the perimeter structure with 6 inch (152 mm) deep steel beams spaced 2 feet (0.6 m) o.c. running parallel to the width. The bottom of the pressure vessel is sheathed with a 7 gauge (4.8 mm) thick steel plate spot welded to the top of the steel beams and continuously welded to the inside perimeter channels.

3.3 The air supply into the sealed vessel is provided by an inlet manifold constructed with 4 inch (102 mm) diameter PVC pipe. Four openings, equally spaced, penetrate the steel plate and serve as the air inlet on the bottom of the pressure vessel. A $^1/_4$ inch (6.4 mm) opening on the bottom of the vessel serves as the manometer connection. A foam gasket that lies between the top channel of the pressure vessel and the sample construction frame minimizes air leakage when the sample is clamped into place.

3.4 Pressurized air is supplied to the inlet manifold by a turbo pressure blower having the capability of generating 600 cubic feet per minute (17 m^3/min). The air flow is regulated by a manually operated 4 inch (102 mm) diameter PVC butterfly valve. Pressure readings are obtained from a water filled manometer calibrated to read directly in pounds per square feet.

4. Test Limitations and Precautions:

4.1 During the test, all testing agency representatives and other test observers shall wear ear and eye protection and hard hats to prevent injury.

4.2 This test procedure may involve hazardous materials, operations and equipment. This protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Test Specimens:

5.1 The components for a proposed test panel are assembled to the desired specifications and details (type and thickness of the deck, application method and rate for the adhesive or fasteners, size and thickness of insulation and type of cover) and then left to "cure" for the manufacturer's specified time period (maximum of 28 days).

5.2 When steel decking is used, it is secured to a 24 feet-7 inch by 12 feet-7 inch by $^1/_4$ inch (7.5 m by 3.8 m by 6.4 mm) angle iron frame. This test specimen frame typically includes a structural steel support located along the centerline and parallel to the length. In addition, three intermediate structural steel supports are located parallel to the width, 6 feet (1.8 m) o.c.. The steel deck is then applied parallel to the length. It is welded to the perimeter angle iron with $^1/_2$ inch (13 mm) diameter puddle welds 12 inch (305 mm) o.c. along the entire perimeter. In addition, it is fastened at all supports [6 feet (1.8 m) spans for 22 gage (0.75 mm) steel] 12 inch (305 mm) o.c. with approved fasteners. All deck side laps are fastened with approved fasteners spaced at a maximum of 30 inch (762 mm) o.c. Other structural roof decks may be used if requested by the program sponsor. Their application is according to the manufacturer's specifications and approval requirements.

Note: The method of securing the steel deck to the test frame may vary when a specific test, as requested by an applicant, dictates.

5.3 When ready for testing, the test specimen frame, containing the test specimen, is placed on the pressure vessel and clamped into place using C-clamps and 2 inch by 3 inch by $^1/_4$ inch (51 mm by 76 mm by 6.4 mm) steel angles placed around the perimeter of the sample [smaller dimension horizontal and the 3 inch (76 mm) leg facing down]. See Figures K1 and K2, herein. In addition, the test specimen frame is secured to the pressure vessel at the three intermediate support clips located near the centerline of the pressure vessel. The appropriate hose connections are then made to the air supply and the manometer.

5.4 Roof system assemblies whose wind-load resistance performance may be affected by bad weather conditions during installation shall be constructed in a manner which simulates actual working conditions.

6. Test Procedure:

6.1 Principal:

6.6.1 The framed roof system assembly test specimen is mounted on the test apparatus and sealed by a foam polyurethane gasket located between the top of the pressure vessel and the bottom of the test specimen frame. Air is supplied to the vessel in increasing amounts to maintain a certain pressure for a given length of time on the underside of the test specimen and to offset minor pressure loss due to leaks. The sustained air pressure delivered to the underside of the test specimen represents the combined positive and negative pressures incurred on an actual roof system assembly from above and below. Pressure is increased until failure occurs.

6.2 After the test specimen is mounted on the test apparatus, air is introduced beneath the sample in accordance with Table J1, below.

TABLE J1
12 FOOT BY 24 FOOT UPLIFT PRESSURE INTERVALS

Time (Minutes)	Static Uplift Pressure[1]	
	psf	kPa
0:01 to 1:00	30	1.4
1:01 to 2:00	45	2.2
2:01 to 3:00	60	2.9
3:01 to 4:00	75	3.6
4:01 to 5:00	90	4.2
5:01 to 6:00	105	4.9
6:01 to 7:00	120	5.7
7:01 to 8:00	135	6.5
8:01 to 9:00	150	7.2

[1] Add 15 psf (0.7 kPa) for each successive one minute interval.

6.3 Prior to and during the attainment of uplift pressures noted above, the test specimen is examined for failure. Upon failure, the test specimen is dismantled and examined to determine the exact mode of failure.

6.4 Record the mode, time and pressure interval of failure.

7. Interpretation of Results:

7.1 The passing uplift pressure shall be the pressure which the test specimen resisted for one minute without failure.

7.2 The minimum passing uplift pressure for an Approved roof system assembly shall be 90 psf (4.2 kPa).

7.3 A 2:1 margin of safety shall be applied to the passing uplift pressure prior to inclusion in the system manufacturer's Product Approval.

7.4 Average wind velocities can vary considerably from area to area. The *Florida Building Code, Building* utilizes a windspeed of 110 mph at a height of 33 feet above ground. These wind velocities in miles per hour are related to the design pressure, in pounds per square feet, for a particular building. Refer to Chapter 16 (High-Velocity Hurricane Zones) of the *Florida Building Code, Building* and ASCE 7.

7.5 Data generated from Appendix J simulated uplift testing may be used for extrapolation, in compliance with RAS 137 (for single-ply membrane attachment), to meet design pressures for a specific building. Extrapolation of data from Appendix J simulated uplift testing is limited to 1.75 times the maximum uplift pressure noted in the Product Approval. Only 'upward' extrapolation is acceptable (i.e., fastener density may not be decreased and fastener spacing may not be increased for lesser design pressures).

TESTING APPLICATION STANDARD (TAS) 114-95
APPENDIX K

TEST PROCEDURES FOR F.I.T. CLASSIFICATION OF MODIFIED BITUMEN ROOF SYSTEM ASSEMBLIES

1. Scope:

1.1 F.I.T. is a performance-based classification for modified bitumen roof membranes. F.I.T. classifications are intended to provide performance capacities required of a particular roof system assembly when different levels of operating conditions are assumed.

1.2 The F.I.T. classification of modified bitumen roof membranes determines their suitability (fitness) for use with respect to the following parameters:

F → Fatigue

I → Indentation (i.e. puncture)

T → Temperature

The classification defines, in terms of these parameters, both the roof system assembly requirements and the membrane performance capabilities to satisfy these requirements.

1.3 Each letter (F, I and T) is assigned a numerical index, thereby providing a brief, yet precise indication of the following parameters:

- the requirements to be satisfied by the roof system assembly; or,
- the performance capabilities of the modified bitumen roof membrane.

The index increases with the severity of the requirements and with the level of performance provided by the roof membrane.

1.4 For each parameter (F, I and T) of the classification, the modified bitumen roof membrane must provide a performance index (number) better than or equal to the requirement of the roof system assembly in question.

2. F.I.T. Classification:

2.1 Classification F—Substrate Movement (Fatigue) Test:

2.1.1 The F classification index is based on results of fatigue testing noted herein. Testing conducted on bonded modified bitumen roof membranes characterizes the membrane resistance to cyclic substrate movement at a given amplitude consisting of 500 cycles for new roof membranes and 200 cycles for aged roof membranes.

2.1.2 Table K1, below, indicates the conditions under which performance indices 1 to 5 are determined.

TABLE K1
CLASSIFICATION F (FATIGUE) PERFORMANCE INDICES

Class	Initial Joint Width (mm)	Amplitude of Joint Movement (mm)	Test Temperature °F(°C)
F_1	1	-0.5 to +0.5	+68 (+20)
F_2	1	-0.5 to +0.5	32 (0)
F_3	2	-1 to +1	32 (0)
F_4	2	-1 to +1	+14 (-10)
F_5	2	-1 to +1	-4 (-20)

2.1.3 Apparatus:

2.1.3.1 The test apparatus shall consist of the following:

- two plates with clamping screws to attached two concrete slabs so that the edges form a butt joint;
- a device to open and close the

joint at a rate of $^{5}/_{8}$ inch per hour (16 mm/hr) and at a controlled amplitude;

- a climactic chamber so the test specimen can be kept at a controlled temperature.

2.1.4 Test specimens:

2.2.4.1 Test specimen shall consist of 12 inch by 2 inch (300 mm by 50 mm) strips of membrane placed on the concrete slabs with the center of the 12 inch dimension centered at the butt joint, which is set at the joint width for the various F classifications noted in Table K1.

2.2.4.2 A total of six test specimen strips shall be tested; three unaged and three which have been conditioned at 176°F (80°C) for 28 days.

2.2.4.3 Specimens shall be fully adhered to the concrete slabs using the method noted in the membrane manufacturer's published literature.

2.1.5 Procedure:

2.1.5.1 From the initial position, the joint is opened and closed alternately under the following conditions:

- the amplitude of movement is + 0.5 mm or + 1 mm, depending on the performance index being tested (see Table K1);
- the test temperature is +68°F, +32°F, +14°F or -4°F depending on the performance index being tested; and,
- the number of cycles is 500 for unaged and 200 for aged specimens.

2.1.6 Observations:

2.1.6.1 The test is terminated at the end of 200 cycles for aged and 500 cycles for unaged specimens at which time:

- the samples are checked for watertightness under a 5 centimeters high water column or by equivalent method; and,
- any loss of bond is observed and reported.

2.1.6.2 Failure criteria shall be complete loss of adhesion or delamination of the specimens.

2.2 Classification I–Static and Dynamic Puncture Test:

2.2.1 The I classification index is based on results of static and dynamic puncture resistance testing noted in Appendix I of TAS 114. Testing conducted on bonded roof membranes characterizes the membrane resistance to static and dynamic impact loading.

2.2.2 Tables K2 through K4, below, indicate the conditions under which performance indices 1 to 5 are determined.

TABLE K2
SUBCLASSIFICATION L (STATIC PUNCTURE) PERFORMANCE INDICES

Subclass	Static Load lb (kg)
L_1	<15 (7)
L_2	>15 (7)
L_3	>33 (15)
L_4	>55 (25)

TABLE K3
SUBCLASSIFICATION D (DYNAMIC PUNCTURE) PERFORMANCE INDICES

Subclass	Impact Energy ft-pdl (J)
D_1	<240 (10)
D_2	>240 (10) <480 (20)
D_3	>480 (20)

TABLE K4
CLASSIFICATION I (INDENTATION) PERFORMANCE INDICES

Class	Subclass L	Subclass D
I_1	L_1	D_2
I_2	L_2	D_2
I_3	L_3	D_2
I_4	L_4	D_2
I_5	L_5	D_3

2.2.3 Apparatus, Procedure and Observations shall be in compliance with Appendix I of TAS 114.

2.3 Classification T–Temperature Stability:

2.3.1 The T classification index is based on results of slippage resistance testing under the effects of temperature noted herein. Testing conducted on bonded modified bitumen roof membranes characterizes the membrane resistance to slippage under the effects of temperature.

2.3.2 Table K5, below, indicates the conditions under which performance indices 1 to 4 are determined.

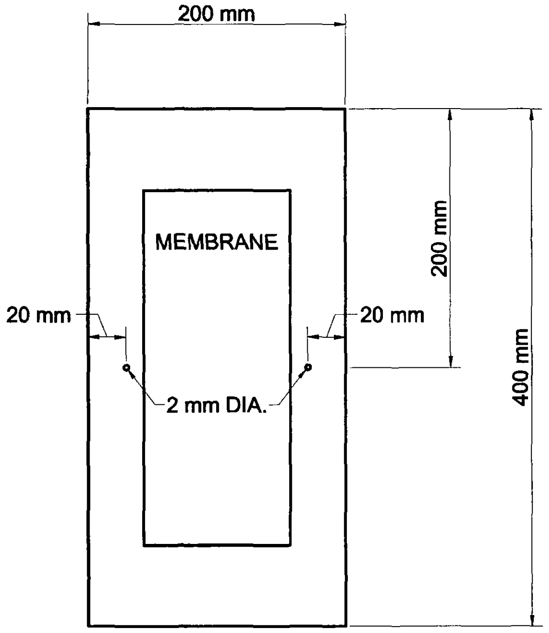
TABLE K5
CLASSIFICATION T (TEMPERATURE STABILITY) PERFORMANCE INDICES

Class	Slippage Amplitude (mm)	Test Temperature °F (°C)
T_1	> 2	140 (60)
T_2	< 2	140 (60)
T_3	< 2	176 (80)
T_4	< 2	194 (90)

2.3.3 Apparatus

2.3.3.1 The test apparatus shall consist of the following:

- A heat chamber controlled to within +5°F, with an operating range from +120°F to not less than +250°F;
- A frame to which the test specimen described below is attached in a sloping position of 45 degrees. The frame must allow the test specimen to be kept in a horizontal position during the time necessary for the selected test temperature to stabilize;
- A series of clean degreased steel plates, 0.08 inch thick by $7^{3}/_{4}$ inch by $15^{3}/_{4}$ inch (2 mm thick by 200 mm by 400 mm), prepared according to Figure K1, below. Each plate has 2 screws and nuts of appropriate diameter for the holes drilled in the edges of the plate.
- A metal rule not less than $7^{3}/_{4}$ inches (200 mm) long.
- A device to measure length to within 0.1 mm.
- Thin aluminum plates 2 inch by 6 inch (50 mm by 150 mm) and a 2-component adhesive.



For SI: 1.02 mm = 0.040 inch

FIGURE K1
SCHEMATIC OF STEEL PLATE FOR TEMPERATURE STABILITY TEST

2.3.4 Test Specimens:

2.3.4.1 Test specimen shall consist of 12 inch by 6 inch (300 mm by 150 mm) membrane samples adhered or torched to the steel plate (do not use primer) in compliance with the membrane manufacturer's published instructions.

2.3.4.2 Put the screws and nuts in place.

2.3.4.3 Glue the aluminum plate to the membrane surface such that it is possible, before and after exposure to heat, to draw a line on the plate with a scribe using a metal rule which is placed against the screws.

2.3.4.4 Three test specimens shall be constructed.

2.3.5 Procedure:

2.3.5.1 Condition the test specimens at ambient conditions in the horizontal position for 24 hours.

2.3.5.2 Draw a line to show the initial position.

2.3.5.3 Set the heat chamber to the required test temperature.

2.3.5.4 Place the test specimen in horizontal position in the heat chamber, and allow it to remain there for one hour.

2.3.5.5 Put the test specimen in the test position, sloping at an angle of 45 degrees, in less than 5 seconds. Keep it in this position at the test temperature for 2 hours.

2.3.5.6 Remove the test specimen from the chamber and allow it to cool at ambient conditions in the horizontal position.

2.3.5.7 Draw a line to indicate the final position.

2.3.6 Observations:

2.3.6.1 Measure the difference between the two lines along each edge.

2.3.6.2 Slippage of the membrane is expressed as the average of the three test specimens.

3. Classification of Membrane Use:

3.1 The ascending order of the indices assigned to each of the F.I.T. letters corresponds to increasingly severe conditions of use.

3.2 Table K6, below, summarizes the classification of the roof system assembly with respect to the three parameters F.I.T. It provides the total classification of the required modified bitumen membrane roof system assembly.

3.2.1 Based on the premise of increasing performance capacity, a modified bitumen membrane classification greater than that required of the roof system assembly would be a wise precaution.

TABLE K6

		Roof Use and Type of Protection					
			Functional Access Roof				Equipment Maintenance Walkway
		Non-Functional	Pedestrian	Vehicles	Pedestrian	Gardens	
Membrane Substrate	Slope	Factory Applied Surfacing	Slabs - Pavers		Protection Slabs on Spacers	Direct Drainage Layer	Factory Applied Surfacing
Thermal Insulation	0	$F_4I_2T_2^{(1)(2)}$			$F_5I_4T_3$	$F_3I_5T_1$	$F_4I_4T_2$
	Low (<4":12")	$F_4I_2T_2^{(1)(2)}$	$F_4I_4T_2$	$F_4I_4T_2$	$F_5I_4T_3$	$F_3I_5T_2$	$F_4I_4T_2$
	Pitched (4":12")	$F_4I_2T_2^{(3)}$					$F_4I_2T_2^{(3)}$
Concrete	0	$F_4I_2T_2$			$F_5I_4T_3$	$F_3I_5T_1$	$F_4I_4T_2$
	Low (<4":12")	$F_4I_2T_2$	$F_4I_4T_2$	$F_4I_4T_2$	$F_5I_4T_3$	$F_3I_5T_2$	$F_4I_4T_2$
	Pitched (4":12")	$F_4I_2T_2$					$F_4I_4T_2$
Concrete & Protected Membrane	0				$F_3I_3T_2$	$F_3I_5T_1$	
	Low (<4":12")		$F_3I_3T_2$		$F_3I_3T_2$	$F_3I_5T_2$	
Cellular Concrete	Low (<4":12")	$F_4I_2T_2$					$F_4I_4T_2$
	Pitched (4":12")	$F_4I_2T_2$					$F_4I_4T_2$
Wood and Derived Panels	Low (<4":12")	$F_4I_2T_2$					$F_4I_4T_2^{(3)}$
	Pitched (4":12")	$F_4I_2T_2^{(3)}$					$F_4I_4T_2^{(3)}$
Existing Membrane	0	$F_4I_2T_2$			$F_5I_4T_3$	$F_3I_5T_1$	$F_4I_4T_2$
	Low (<4":12")	$F_4I_2T_2$	$F_4I_4T_2$	$F_4I_4T_2$	$F_5I_4T_3$	$F_3I_5T_2$	$F_4I_4T_2$
	Pitched (4":12")	$F_4I_2T_2^{(3)}$					$F_4I_4T_2^{(3)}$

1 Index I becomes I_3 for mineral wool over concrete and cellular concrete.

2 Index I becomes I_3 on $R > 2m^2$ °C/W mineral wool.

3 Index T becomes T_3 if $R > 2m^2$ °C/W.

TESTING APPLICATION STANDARD (TAS) 116-95

TEST PROCEDURE FOR AIR PERMEABILITY TESTING OF RIGID, DISCONTINUOUS ROOF SYSTEMS

1. Scope:

1.1 This protocol covers the determination of the air permeability characteristics of a rigid, discontinuous roof system.

1.2 The test procedures outlined herein shall be used to determine the air pressure difference (DP) and the air volume flow rate (Q) which occur across the rigid, discontinuous roof system when the air flow rate into a sealed chamber beneath the system is such that the moment incurred on the rigid components within the system is equal to 90 percent of the restoring moment due to gravity (M_g) of the rigid components.

1.3 The calculations outlined herein shall be used to determine the air permeability (C_d) for the system being tested.

1.4 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a professional engineer or registered roof consultant.

2. Referenced Documents:

2.1 *The Florida Building Code, Building.*

2.2 *Application Standards*

TAS 108	Test Procedure for Wind Tunnel Testing of Air Permeable, Rigid, Discontinuous Roof Systems

2.3 *The British Standard BS5534–Appendix A.5.1.*
Method of Test for the Air Permeability Factor D of Unsealed Small Element Roof Assemblies

2.4 *ASTM Standards*:

E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.5 *Roof Consultants Institute:*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions–For definitions of terms in this Protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building* and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 Use of this protocol is limited to manufacturers of rigid, discontinuous roof systems who desire to have their system(s) tested for wind characteristics in compliance with TAS 108. This limits the protocol's use to discontinuous roof system in which the unsealed, overlapping, rigid components have a length between 1.0 and 1.75 feet; an exposed width between 0.73 and 1.25 feet; and a thickness not greater than 1.3 inches.

4.2 The procedures and calculations outlined herein provide a means of determining the air permeability (C_d) for a rigid, discontinuous roof system. This value shall be listed in the system manufacturer's roof system assembly Product Approval for reference by the chief code compliance officer to determine whether the system is air permeable or air impermeable. The Chief Code Compliance Officer may nullify this testing requirement for systems which are generally considered air permeable.

4.3 The test criteria will be based on testing, under the provisions of this Protocol, of rigid, prepared roof coverings which are generally considered air impermeable (i.e. metal roof systems, and lap sealed, rigid prepared roof coverings). This criteria shall be determined by September 1, 1994. Until that date, the Chief Code Compliance Officer shall judge as to whether a prepared roof covering is air permeable or air impermeable.

5. Apparatus

5.1 The pressure from beneath the system shall be generated in a sealed, rectangular plenum chamber having a depth not less than 2 feet. The chamber shall be airtight with the exception of an open upper face; a tapping for a pressure tube; and an air inlet pipe. The chamber shall be of sufficient dimensions to receive a wood deck on which the minimum number of rigid components, noted in Section 8.5, shall be installed. (See Figure 1, attached.)

5.2 The pressure tapping, noted in Section 5.1, shall be positioned on the chamber so as to avoid direct alignment with the air inlet pipe. The pressure tube shall be connected to a manometer or an electrical pressure transducer to measure the pressure within the chamber relative to that outside the chamber. The pressure tapping shall be fully sealed around the pressure tube.

5.3 The air inlet pipe shall be connected to an electric fan which is capable of producing a continuous air volume flow of 7 ft^3/s through the air inlet pipe. The connection between the air inlet pipe and the chamber shall be fully sealed around the perimeter of the air inlet pipe. The air inlet pipe shall be equipped with an air flow meter capable of measuring an air volume flow rate (Q) of not less than 9.0 ft^3/s and having an accuracy of 0.1 ft^3/s.

5.4 An airtight removable cover panel shall be used to check the air tightness of the plenum chamber, as noted in Section 5.3.

5.5 A weighing device with an accuracy of 0.05 lb shall be used to determine the average mass of the rigid components which make up the prepared roof covering.

6. Precautions

6.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Apparatus Checks— the following steps shall be conducted prior to any air permeability testing.

7.1 The pressure tube from the plenum chamber to the manometer device shall be checked for leakage by applying a constant pressure within the tube and clamping it off. Leakage shall be identified by any pressure drop recorded by a pressure measuring device. Any pressure tube which exhibits leakage shall be repaired or replaced.

7.2 The manometer, if utilized, shall be cross-checked against an electrical pressure transducer.

7.3 Airtightness Check

7.3.1 Close the top of the plenum chamber by attaching and sealing the edges of the cover panel so that the plenum chamber is air tight with the exception of the inlet pipe.

7.3.2 Supply air from the electric fan through the inlet pipe to induce a pressure difference between the inside and outside of the plenum chamber of not less than 10.5 pounds per square feet.

7.3.3 If this pressure can be maintained for a period of 1 minute with an air pressure flow rate not greater than 0.2 ft^3/s, the airtightness shall be considered satisfactory.

8. Test Specimen

8.1 Substrate

8.1.1 The substrate shall consist of APA $^{32}/_{16}$ span rated sheathing of $^{15}/_{32}$ inch thickness, attached with 8d common nails at 6 inch o.c. at panel edges and 12 inch o.c. at intermediate supports, and an underlayment. The underlayment shall consist of a No. 30 ASTM D 226, type II asphalt saturated anchor sheet, mechanically attached to the sheathing with approved nails and tin caps spaced in a 12 inch grid staggered in two rows in the field and 6 inch o.c. at laps. Over the anchor sheet, one layer ASTM D 249 mineral surfaced cap sheet shall be applied in a full mopping of ASTM D 312, type IV asphalt. Side laps (if any) shall be 6 inches and head laps (if any) shall be 2 inches, nailed 12 inches o.c. and 6 inches o.c., respectively.

8.1.2 The substrate, consisting of the wood deck and the underlayment, shall have 3 inch holes spaced 6 inches across its width in staggered rows spaced 6 inches along its length to allow for airflow into the system.

8.1.3 The substrate perimeter shall be completely sealed when placed in the plenum chamber.

8.2 Mortar (if a mortar set tile system assembly)

8.2.1 Mortar mix shall have a roofing Component Product Approval for use with the mortar set tile system and shall be in compliance with TAS 123.

8.2.2 Mortar shall be mixed using the mixing ratio specified in the mortar manufacturer's Product Approval.

8.2.3 Mortar flow shall be determined using a cone penetrometer test, in compliance with ASTM C 780 (Appendix A1), the results of which shall be $2^1/_8 + ^1/_8$ inch (55 + 3 mm) of penetration.

8.3 Adhesive (if an adhesive set tile system assembly)

8.3.1 Adhesive shall have a roofing component Product Approval for use with the adhesive set tile system which is being tested and shall be applied in compliance with the provisions set forth in that Approval.

8.4 Fasteners (if applicable):

8.4.1 Component attachment fasteners (i.e., nails, screws, tile straps, etc.) shall be those recommended in the prepared roof covering manufacturer's published installation instructions. Minimum nails shall be 12 gage ring shank, hot dipped galvanized roofing nails. Minimum screws shall be #8 diameter screw fasteners.

8.5 Battens (if applicable)

8.5.1 Horizontal Batten System

- Horizontal battens shall be of nominal 1 inch by 2 inch dimensional lumber and shall be spaced to provide a minimum 3 inch head lap, or to match the interlocking configuration of the component's profile.
- Horizontal battens shall be nailed to the wood test deck at 6 inch o.c. using 12 gage roofing nails.

8.5.2 Counter Batten System:

- Vertical battens shall be of nominal 1 inch by 4 inch lumber and shall be spaced 24 inches over the intermediate supports (trusses).
- Vertical battens shall be nailed to the wood test deck at 6 inches o.c. using 12 gage roofing nails.
- Horizontal battens (counter battens) shall be as noted in Section 8.5.1, nailed to the 1 inch by 4 inch vertical battens using 12 gage roofing nails of sufficient length to penetrate both battens.

8.5.3 If the system being tested is installed over battens, the battens shall be installed prior to drilling the 3 inch holes noted in Section 8.1.2.

8.6 Rigid components:

8.6.1 Rigid components shall meet the size requirements listed in Section 4.1.

8.6.2 Rigid components shall be attached or bonded in compliance with the system manufacturer's published installation instructions and the minimum requirements of the *Florida Building Code, Building*. For mechanically attached, direct deck applications, care shall be taken so as to avoid direct alignment of the fastening line for each course with the staggered rows of 3 inch holes in the substrate, noted in Section 7.1.2. For mortar or adhesive applications, care shall be taken to avoid mortar or adhesive application over these holes. If this is unavoidable due to the configuration/spacing of the rigid components within the system, the holes shall be cleared of excess mortar or adhesive prior to the material hardening.

8.6.3 The number of rigid components to be installed on the substrate, unsealed, shall be in compliance with Table 1, below.

TABLE 1
NUMBER OF COURSES AND NUMBER OF COMPONENTS PER COURSE

Component Type	Minimum Number of Courses	Minimum Number per Course
Single Lap	2	2
Plain Tiles (bonded or mechanically attached)	2	4
Slates	2	2

8.6.4 In addition to the number of components listed in Table 1, a sufficient number of components shall be provided to cover the perimeter area of the substrate. These components shall be completely sealed at all laps, front and side joints with approved adhesive.

9. Preliminary Measurements and Calculations:

9.1 Average mass, weight and restoring moment due to gravity (M_g):

9.1.1 Determine the mass of each rigid component to be installed and calculate the average mass.

9.1.2 Determine the average weight of the rigid components using the average mass and the following equation.

$$W = m \times \frac{1\ slug}{32.174\ lbm} \times g \qquad \text{where,}$$

W = average component weight (lbf);

m = average component mass (lbm); and,

g = 32.2 ft/s^2 = acceleration of gravity constant.

Note: 1 slug = 1 lbf s^2/ ft

9.1.3 Determine the restoring moment due to gravity (M_g) from the center of the exposed area about the head of the rigid component using the component's average weight and the following equation.

$$M_g = W \times l \qquad \text{where,}$$

M_g = restoring moment due to gravity (ft-lbf);

W = average component weight (lbf); and

l = moment arm (ft) (distance from center of exposed area to the head of the component)

9.2 Pressure to Induce Moment (p)

9.2.1 Determine the upward pressure required to induce the restoring moment due to gravity, determined above, using the following equation.

$$p = \frac{M_g}{b \times l_0 \times l} \qquad \text{where,}$$

p = pressure required to induct moment (lbf/ft^2);

M_g = restoring moment due to gravity (ft-lbf);

b = component cover width (ft);

l_o = component exposed length (ft) = total length - headlap dimension; and l = moment arm (ft) (distance from center of exposed area to the head of the component)

9.3 Effective Area (a):

9.3.1 Determine the effective area (a) (i.e., the area having unsealed components) across which the pressure difference will occur using the following equation.

$$a = N \times b \times l_o \quad \text{where,}$$

a = effective area (ft^2);

N = number of unsealed components;

b = component cover width (ft); and

l_o = component exposed length (ft)

= total length–headlap dimension

10. Test Procedure:

10.1 Position the test specimen in the plenum chamber, insuring that both the substrate perimeter and the perimeter rigid components are completely sealed.

10.2 Supply air through the inlet pipe to the plenum chamber, gradually increasing the airflow until the manometer indicates a pressure difference (ΔP) equal to 90 percent of the pressure (p) determined in Section 9.2.

10.3 When the pressure difference (ΔP) reaches this point, record the pressure difference (ΔP) and the air volume flow rate (Q) and gradually reduce the air supply to zero.

10.4 Repeat this test procedure three times using the same test specimen. If any evidence of damage exists subsequent to any test, construct an additional test specimen for the additional test(s).

11. Calculations:

11.1 Determine the air permeability (C_d) using information gathered from preliminary calculations, testing procedures and the following equation.

$$C_d = \frac{Q}{a \times \sqrt{\dfrac{2 \times \Delta P}{\rho}}} \quad \text{where,}$$

C_d = air permeability (dimensionless);

Q = air volume flow rate (ft^3/s);

a = effective area (ft^2);

ΔP = pressure difference (lbf/ft^2); and

ρ = density of air = 2.377 x 10-3 slugs/ft^3

11.2 Determine the average air permeability for the three tests conducted.

12. Report:

12.1 The final test report shall include the following:

12.1.1 The type, name, and manufacturer of the discontinuous roof system and the dimensions of the rigid components within the system.

12.1.2 A detailed report of the system installation prepared by a professional engineer or registered roof consultant, including a sketch of the installed system, indicating the sealed and unsealed components, and the published installation instructions provided by the system manufacturer.

12.1.3 Data and calculations for average mass (m); average weight (W); restoring moment due to gravity (M_g); pressure required to induce moment (p); and effective area (a).

12.1.4 Pressure difference (ΔP) and air volume flow rate (Q) readings at the point when the pressure needed to incur moment is attained.

12.1.5 Calculations and results for the air permeability (C_d) of the three tests and the average value.

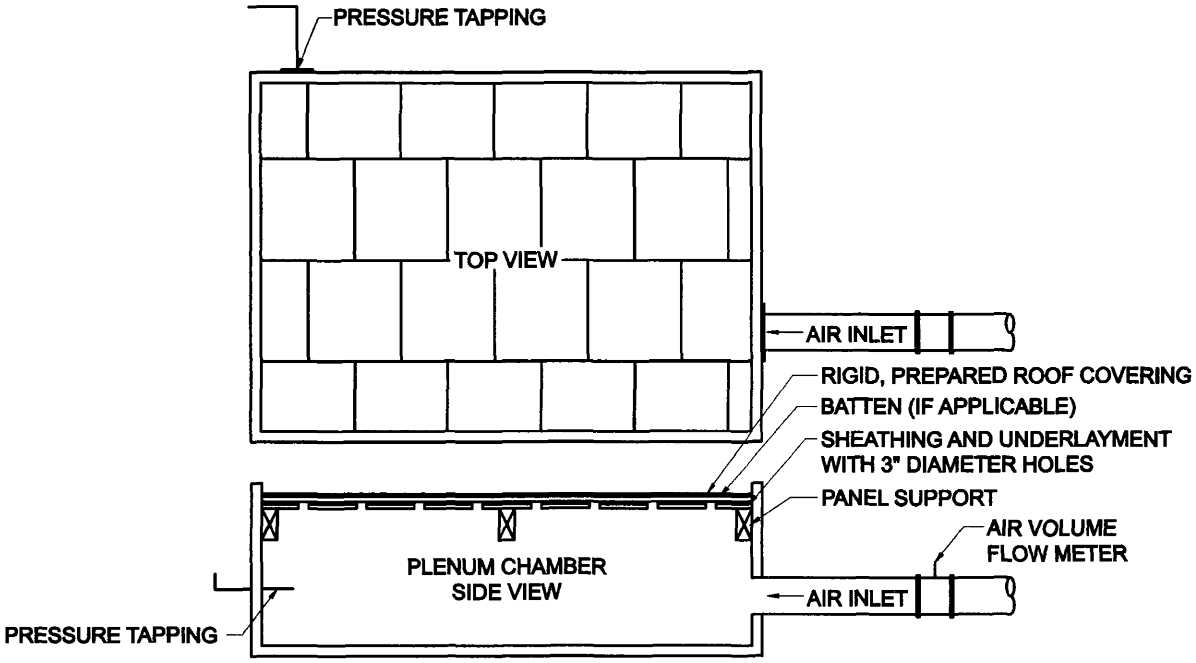


FIGURE 1
AIR PERMEABILITY TEST APPARATUS

TESTING APPLICATION STANDARD (TAS) 117(A)-95

TEST PROCEDURE FOR WITHDRAWAL RESISTANCE TESTING OF MECHANICAL FASTENERS USED IN ROOF SYSTEM ASSEMBLIES

1. Scope:

1.1 This protocol covers determination of the withdrawal resistance performance of fasteners used for the mechanical attachment of anchor sheets, insulation panels, base sheets and single ply membranes when installed in various substrates and exposed to axial symmetric loading.

1.2 The test procedures outlined herein utilize both static and pulsating loads. In the case of asymmetrical loading, the test results shall be evaluated separately.

1.3 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a professional engineer or registered roof consultant.

2. Referenced Documents:

2.1 *The Florida Building Code, Building.*

2.2 *ASTM Standards*

D 1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.3 *Norwegian Building Research Institute* Roofing Systems With Mechanical Attachments

3. Terminology & Units:

3.1 Definitions—For definitions of terms in this protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building* and ASTM D 1079. Definitions from the *Florida Building Code, Building* shall take precedence.

3.1.1 The withdrawal resistance value under static load shall be defined as the mean load capacity obtained during testing under static load.

3.1.2 The withdrawal resistance value under pulsating load shall be defined as the mean capacity obtained, or the mean capacity when permanent deformation greater than 0.25 inch (6.3 mm).

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 The test procedure provides a means of determining of the withdrawal resistance performance of fasteners used for the mechanical attachment of anchor sheets, insulation panels, base sheets and single ply membranes when installed in various substrates and exposed to axial symmetric loading. The test procedure is acceptable for all types of fasteners used for the mechanical attachment of roof coverings, such as self-threading screws, various types of expansion anchors, wood deck fasteners, nails, etc. The substrate material may be steel, concrete, gypsum, cementitious wood fiber, lightweight concrete, wood, or composite deck systems.

5. Sampling:

5.1 Samples shall be tested as delivered and shall be provided directly from the fastener manufacturer. Unless otherwise specified, 14 samples shall be tested for each type of load (i.e., 14 for static load and 14 for pulsating load).

6. Test Method:

6.1 General:

6.1.1 The withdrawal resistance value under static load is determined through uniformly increased load applied to the fastener. For structural concrete, this uniform load increase is based on vertical deflection rate of $^1/_2$ inch (12 mm) per minute. For all other deck types, this uniform load increase is based on vertical deflection rate of 2 inches (50 mm) per minute.

6.1.2 The withdrawal resistance value under pulsating load is determined through incrementally increased pulsating load applied to the fastener.

6.2 Apparatus:

6.2.1 A tensile loading device which can be operated with both static and pulsating tensile forces.

6.2.2 A load cell to measure the applied load.

6.2.3 A deflection or deformation gauge.

6.2.4 A holding device.

6.2.5 A load transfer device for applying load to the fastener. The top disc shall bear on a steel plate having a $^7/_{16}$ inch (11 mm) slot and a 1.2 inch (30 mm) diameter hole.

6.3 Preparation of test samples:

6.3.1 The fasteners shall not be prepared in any way; however, fasteners shall be installed in compliance with the fastener manufacturer's published installation instructions using the installation tool recommended by the fastener manufacturer for deck type being tested. If the tested fastener is designed for use as an insulation fastener, the fastener shall be installed through insulation.

6.3.2 Substrate–metal decks:

- The fastener samples shall be installed into the top flange of the metal profile, not in the flute. Fastener samples shall be installed as close to the center of the top flange as possible.
- Fasteners shall be tested on the day of installation.
- A minimum of 14 samples shall be tested for each type of load (i.e., 14 for static load and 14 for (pulsating load).

6.3.3 Substrate—structural concrete decks:

- Unless otherwise specified, structural concrete test samples shall be 12 inch by 12 inch square by 3 inch thick (300 mm by 300 mm by 76 mm) slabs having a compressive strength of 3,000 psi.
- Concrete test samples shall have cured for a minimum of 28 days prior to fastener installation. Fasteners shall be tested on the day of installation. Not more than 3 fastener samples shall be installed per concrete slab.
- The predrilled hole for each fastener sample shall be at not less than $^1/_2$ inch (12 mm) deeper than the required attachment depth for the fastener sample to allow for concrete powder fill in the predrilled holes. It is acceptable for the predrilled hole to penetrate the concrete substrate sample.
- A minimum of 14 samples shall be tested for each type of load (i.e., 14 for static load and 14 for pulsating load).

6.3.4 Substrate–gypsum decks:

- Gypsum test samples shall be 6 inch diameter by 3 inch deep (150 mm diameter by 76 mm deep) poured gypsum cylinders or 6 inch by 6 inch square by 3 inch deep poured gypsum blocks.
- Gypsum test samples shall have cured for a minimum of 28 days prior to fastener installation and fasteners shall

- be tested on the day of installation. Not more than 1 fastener sample shall be installed per gypsum cylinder.
- A minimum of 14 samples shall be tested for each type of load (i.e., 14 for static load and 14 for pulsating load).

6.3.5 Substrate—cementitious wood fiber decks:

- Cementitious wood fiber test samples shall be 6 inch by 6 inch (150 mm by 150 mm) samples having a thickness of 2 inches, 2 $^1/_4$ inches, 2$^1/_2$ inches or 3 inches (50 mm, 57 mm, 63 mm or 76 mm).
- Cementitious wood fiber test samples require no curing time prior to fastener installation. Fasteners shall be tested on the day of installation. Not more than 1 fastener sample shall be installed per cementitious wood fiber sample.
- A minimum of 14 samples shall be tested for each type of load (i.e., 14 for static load and 14 for pulsating load).
- Results from fastener testing in thinner substrate samples may be utilized as a design value for applications over a thicker substrate (i.e., results from fastener testing in 2 inch substrate samples may be utilized as design values in 3 inch cementitious wood fiber). However, results from testing in thicker substrate samples may not be utilized as a design value for applications over thinner substrates.

6.3.4 Substrate–Lightweight concrete decks (aggregate, cellular or hybrid):

- Lightweight concrete test samples shall be 6 inch by 6 inch by 3 inch deep (150 mm by 150 mm by 76 mm deep) poured lightweight concrete samples.
- Two sets of 14 lightweight concrete test samples shall be tested for withdrawal resistance under static load. The first set of 14 samples shall have cured 3 days prior to fastener installation. The second set of 14 samples shall have cured 28 days prior to fastener installation. Fasteners in both sets of 14 lightweight concrete samples shall be tested on the 28th day of curing. Not more than 1 fastener sample shall be installed per lightweight concrete sample.
- The withdrawal resistance value under static load shall be the greater of the two mean values determined in compliance with Sections 6.4.1 and 6.5, herein.
- A minimum of 14 samples shall be tested for withdrawal resistance under pulsating load using the withdrawal resistance value under static load, noted above, to determine the pulsating load interval noted in Section 6.4.2. Test samples for withdrawal resistance under pulsating load shall be constructed in the same manner as those which yielded the withdrawal resistance value under static load.

6.4 Procedure:

6.4.1 Withdrawal resistance under static loading:

- The withdrawal resistance under static load shall be tested first.
- The test specimen, consisting of the installed fastener and substrate samples, shall be secured in the tensile loading device in such a manner that any bending or shear loads are avoided.
- The tensile loading device shall be operated at a vertical deflection rate of $^1/_2$ inch (12

mm) per minute for testing in structural concrete and a vertical deflection rate of 2 inches (50 mm) per minute for testing in all other substrates.

- The withdrawal resistance value under static load shall be the mean of 12 test results after eliminating the 'high' value and the 'low' values, providing the statistical analysis criteria, noted in Section 6.5, are met.
- The withdrawal resistance value under static load shall be calculated and documented prior to testing for withdrawal resistance under pulsating load.

6.4.2 Withdrawal resistance under pulsating loading:

- The withdrawal resistance under pulsating load shall be tested using the documented withdrawal resistance value under static load, determined above.
- The initial pulsating load interval shall be $^1/_5$ of the withdrawal resistance value under static load after this value is rounded to the next whole 10 lbf (45 N).
- Pulsating load interval increments shall be $^1/_5$ of the withdrawal resistance value under static load after this value is rounded to the next whole 10 lbf (45 N). The minimum load increment shall be 10 lbf (45 N).
- Each pulsating load interval shall consist of 200 load cycles (i.e., loading and unloading). Subsequent to each pulsating load interval, the tensile loading device shall be set to the next pulsating load interval, increasing the previous load interval by the predetermined load interval increment, until failure occurs.
- For tests which exhibit elastic deformation, the load cycle speed is increased at pulsating load interval #3 and in all subsequent intervals. The intent is to maintain the same total testing time as in pulsating load interval #2. Deformations at each load interval shall be recorded.

6.5 Statistical analysis of results:

6.5.1 Eliminate the 'high' and 'low' values recorded during withdrawal resistance testing under static load and calculate a mean and a standard deviation from the remaining 12 recorded values using the following equations.

$$F = \frac{1}{12}\sum_{i=1}^{12} F_i \qquad \text{and,}$$

$$S_F = \sqrt{\frac{1}{11}\sum_{i=1}^{12}\left(F_i - \overline{F}\right)^2} \qquad \text{where,}$$

$\overline{F}$ = mean load;

S_F = standard deviation;

F = record load; and,

i = test number

6.5.2 Determine the percent deviation from the mean (S'_F) using the following equation.

$$S'_F = \left(\frac{S_F}{F}\right) \times 100$$

If the percent deviation from the mean (S'_F) is greater than 20 percent, then the test results shall be considered null and void and the withdrawal resistance performance under static load shall be retested.

6.5.3 Eliminate the 'high' and 'low' values recorded during withdrawal resistance testing under pulsating load and calculate a mean and a standard deviation from the remaining 12 recorded values using the equations noted in Section 6.5.1.

7. Report:

7.1 The final test report shall include the following relevant information:

- 7.1.1 Name and address of the testing laboratory.
- 7.1.2 Identification number of the test report.
- 7.1.3 Name and address of the organization or the person who ordered the test.
- 7.1.4 Purpose of the test.
- 7.1.5 Method of sampling and other circumstances (date and person responsible for the sampling).
- 7.1.6 Name and address of manufacturer or supplier of the tested object.
- 7.1.7 Name or other identification marks of the tested object.
- 7.1.8 Description of the tested object.
- 7.1.9 Date of supply of the tested object.
- 7.1.10 Date of the test.
- 7.1.11 Test method.
- 7.1.12 Conditioning of the test specimens, environmental data during the test (temperature, pressure, RH, etc.).
- 7.1.13 Identification of the test equipment and instruments used.
- 7.1.14 Any deviations from the test method.
- 7.1.15 Test results and statistical analysis computations.
- 7.1.16 Date and signature.

TESTING APPLICATION STANDARD (TAS) 117(B)-95

TEST PROCEDURE FOR DYNAMIC PULL-THROUGH PERFORMANCE OF ROOFING MEMBRANES OVER FASTENER HEADS OR FASTENERS WITH METAL BEARING PLATES

1. Scope:

1.1 This protocol covers determination of the dynamic pull-through performance of roofing membrane when fastened with individual fasteners having integral or separate metal bearing plates.

1.2 This protocol is not applicable to plastic bearing plates. For plastic bearing plates refer to TAS 117, Appendix C.

1.3 The test procedures outlined herein utilize a cumulative loading procedure.

1.4 All testing and calculations shall be conducted by a certified testing agency and all test reports, including calculations, shall be signed and sealed by a professional engineer or registered roof consultant.

2. Referenced Documents:

2.1 *The Florida Building Code, Building.*

2.2 *Application Standards*
TAS 117(C)Test Procedure for Dynamic Pull-Off Performance of Roofing Fastener Heads or Fasteners with Bearing Plates

2.3 *ASTM Standards*

D 1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.4 *Norwegian Building Research Institute*
Roofing Systems With Mechanical Attachments

3. Terminology & Units:

3.1 Definitions–For definitions of terms in this Protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building* and ASTM D 1079. Definitions from the *Florida Building Code, Building* shall take precedence.

3.1.1 All references to 'metal bearing plate' are interchangeable with 'metal stress plate.'

3.1.2 The dynamic pull-through value under cumulative loading shall be defined as the mean load capacity obtained at failure. Failure shall be defined as any of the following:

- pull through of the fastener head or bearing plate in the membrane;
- tearing of the membrane around the fastener head, bearing plate or fastener stem; or,
- breakage of the fastener, fastener head or bearing plate or permanent deformation of the bearing plate in excess of $^1/_4$ inch (6.3 mm).

3.2 Units–For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 The test procedure provides a means of determining of the dynamic pull-through performance of roofing membranes when fastened with individual fasteners having integral or separate bearing plates and exposed to cumulative loading.

4.2 The test procedure is acceptable for all types of roofing membranes, fasteners with integral bearing plates and fasteners with separate bearing plates.

Note: Roofing nails or cap nails are not approved for use within the high-velocity hurricane zone jurisdiction. Therefore, results from testing membranes with these nail types shall not be utilized as design values for projects within this jurisdiction. In addition, the minimum and maximum bearing plate diameters for anchor or base sheet attachment within the high-velocity hurricane zone jurisdiction are $1^{5}/_{8}$ inches (41 mm) and 2 inches (51 mm), respectively. Therefore, results from testing membranes with bearing plates having a diameter less than $1^{5}/_{8}$ inches (41 mm) or greater than 2 inches (51 mm) shall not be utilized as design values for projects within this jurisdiction.

5. Sampling:

5.1 Membrane, fastener and/or bearing plate samples shall be provided directly from the respective manufacturer and shall be tested as delivered. Unless otherwise specified, 14 samples shall be tested for each variable in the test specimen (i.e., different membrane, different fastener or different bearing plate).

6. Test Method:

6.1 General:

6.1.1 The dynamic pull-through value is determined by subjecting the test specimen to a cumulative load until failure occurs.

6.2 Apparatus:

6.2.1 A tensile loading device which can be operated with uniform, continuous static, tensile forces.

6.2.2 A load cell to measure the applied load.

6.2.3 A deflection or deformation gauge.

6.2.4 A holding device:

- For test specimens which include a fastener with a bearing plate having a diameter greater than or equal to $1^{5}/_{8}$ inches (41 mm), whether the plate is integral to the fastener or not, the test specimen holding device shall consist of a 18 inch by 18 inch (457 mm by 457 mm) nail-studded metal frame (See Figure 1, attached).
- Lap fasteners shall be installed through 2 inch (50 mm) insulation and pretensioned against a 6 inch by 6 inch by $^{19}/_{32}$ inch (150 mm by 150 mm by 15 mm) plywood load-application plate. Lapped test specimens shall have the lap installed on the inside of the metal frame (See Figure 2, attached).
- For test specimens which include a roofing or cap nail, the test specimen holding device shall consist of a 5 inch (125 mm) diameter clamping ring (See Figure 3, attached). **See Note 1 in Section 4.2, herein.**

6.3 Preparation of test samples:

6.3.1 The fasteners shall not be prepared in any way; however, care shall be taken to insure that fasteners are mounted in the test specimen in a defined, consistent manner.

6.3.2 For dynamic pull-through testing of membrane over a fastener head or fastener with bearing plate, the fastener assembly sample shall be installed through the center of the test specimen.

6.3.3 For dynamic pull-through testing of lapped test specimens, normal pre-tension shall be applied to the fastener assembly against 2 inch (50 mm) thick polyisocyanurate insulation with a compressive strength not less than 20 psi. The lapped membrane shall be installed on the inside of the metal frame with the fastener assembly test sample installed as close as possible to the center of the test specimen.

6.3.4 For dynamic pull-through testing of membrane over a roofing or cap nail, the nail sample shall be installed through the center of the test specimen. **(See Note 1 in Section 4.2, herein)**

6.3.5 Dynamic pull-through testing shall be conducted in a room with controlled temperature and humidity, 73°F (23 ± 2°C) and RH 50 percent.

6.4 Procedure:

6.4.1 The test specimen, consisting of the membrane sample and fastener assembly sample mounted in the appropriate holding device, shall be secured in the tensile loading device in such a manner that any bending or shear loads are avoided.

6.4.2 The tensile loading device shall be operated at a vertical deflection rate of 2 inch per minute (50 mm/min).

6.4.3 Figure 4, attached shows a photograph of dynamic pull-through testing.

6.5 Statistical analysis of results:

6.5.1 Eliminate the 'high' and 'low' values recorded during the dynamic pull-through testing and calculate a mean and a standard deviation from the remaining 12 recorded values using the following equations.

$$\overline{F} = \frac{1}{12}\sum_{i=I}^{12} F_i$$

$$S_F = \sqrt{\frac{1}{11}\sum_{i=I}^{12}\left(F_i - \overline{F}\right)^2}$$ where,

$\overline{F}$ = mean load;

S_F = standard deviation;

F = record load; and,

i = test number

6.5.2 Determine the percent deviation from the mean (S'_F) using the following equation.

$$S'_F = \left(\frac{S_F}{\overline{F}}\right) \times 100$$

If the percent deviation from the mean (S'_F) is greater than 20 percent, then the test results shall be considered null and void and the dynamic pull-through performance under cumulative loading shall be retested.

7. Report:

7.1 The final test report shall include the following relevant information:

7.1.1 Name and address of the testing laboratory.

7.1.2 Identification number of the test report.

7.1.3 Name and address of the organization or the person who ordered the test.

7.1.4 Purpose of the test.

7.1.5 Method of sampling and other circumstances (date and person responsible for the sampling).

7.1.6 Name and address of manufacturer or supplier of the tested object.

7.1.7 Name or other identification marks of the tested object.

7.1.8 Description of the tested object.

7.1.9 Date of supply of the tested object.

7.1.10 Date of the test.

7.1.11 Test method.

7.1.12 Conditioning of the test specimens, environmental data during the test (temperature, pressure, RH, etc.).

7.1.13 Identification of the test equipment and instruments used.

7.1.14 Any deviations from the test method.

7.1.15 Test results and statistical analysis computations.

7.1.16 Date and signature.

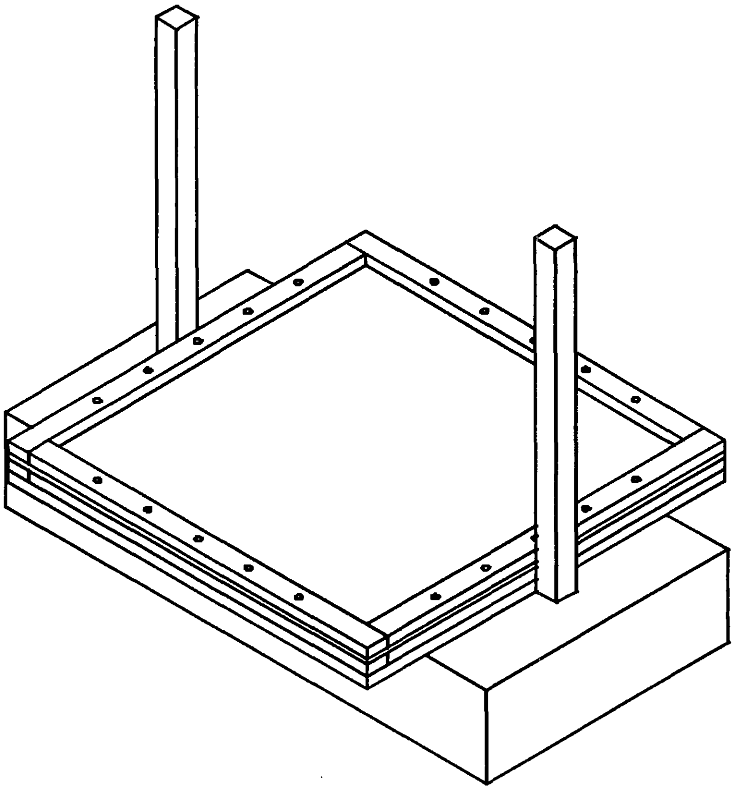


FIGURE 1
HOLDING DEVICE CONFIGURATION

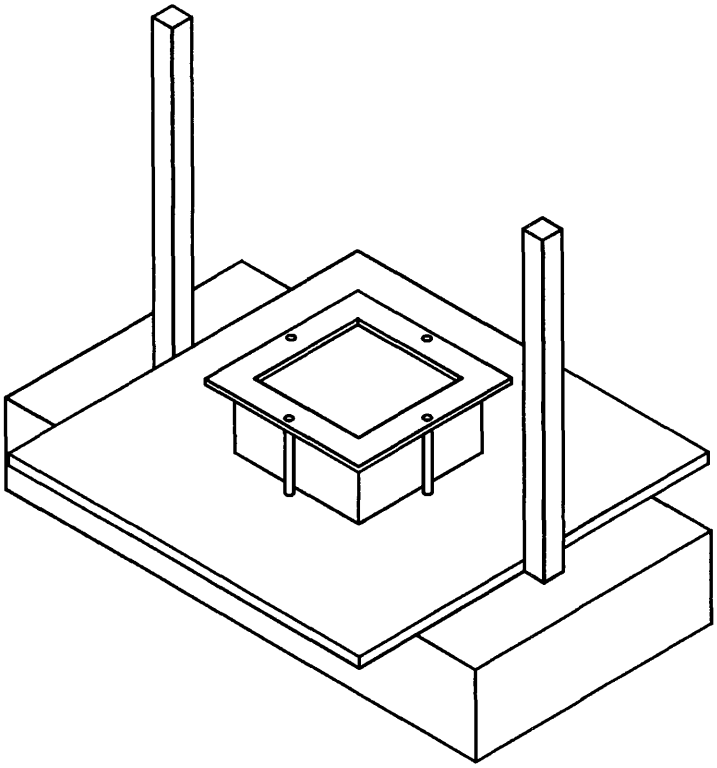
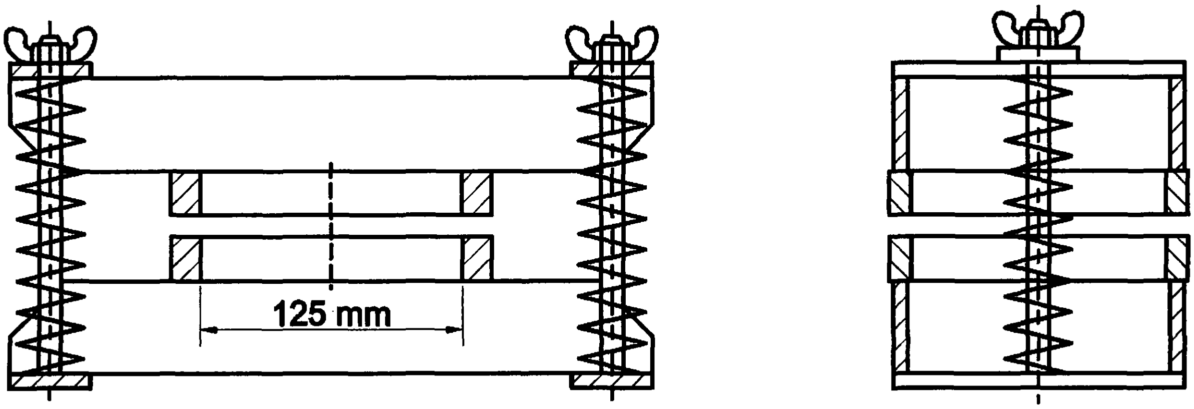


FIGURE 2
HOLDING DEVICE CONFIGURATION FOR LAPPED TEST SPECIMENS



LONGITUDINAL SECTION

CROSS SECTION

For SI: 1.02 mm = 0.040 inch.

FIGURE 3
HOLDING DEVICE CONFIGURATION FOR ROOFING OR CAP NAIL TESTING
(SEE NOTE IN SECTION 4.2 HEREIN)

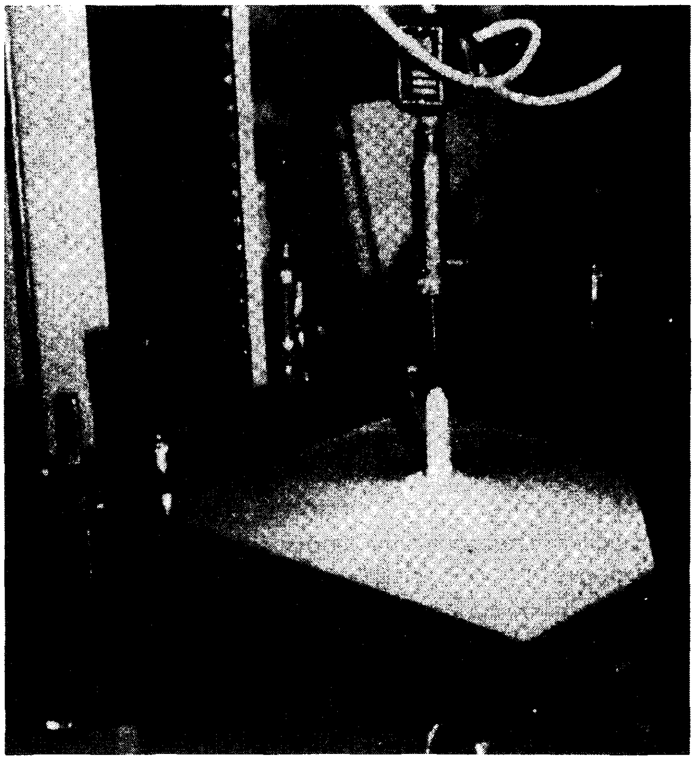


FIGURE 4
VIEW OF DYNAMIC PULL-THROUGH TESTING

TESTING APPLICATION STANDARD (TAS) 117(C)-95

TEST PROCEDURE FOR DYNAMIC PULL-OFF PERFORMANCE OF ROOFING FASTENER HEADS OR FASTENERS WITH BEARING PLATES

1. Scope:

1.1 This protocol covers determination of the dynamic pull-off performance of roofing fastener heads or fasteners with bearing plates.

1.2 This protocol is applicable to both metal and plastic bearing plates. Metal bearing plates shall also be tested for dynamic pull-through resistance with roofing membranes in compliance with TAS 117(B).

1.3 The test procedures outlined herein utilize a dynamic eccentric loading procedure.

1.4 All testing and calculations shall be conducted by a certified testing agency and all test reports, including calculations, shall be signed and sealed by a professional engineer or registered roof consultant.

2. Referenced Documents:

2.1 *The Florida Building Code, Building*

2.2 *Application Standards:*

TAS 117(B)	Test Procedure for Dynamic Pull-Through Performance of Roofing Membranes Over Fastener Heads or Fasteners with Metal Bearing Plates

2.3 *Norwegian Building Research Institute:* Roofing Systems with Mechanical Attachments

2.4 *ASTM Standards:*

D 1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

3. Terminology & Units:

3.1 Definitions–For definitions of terms in this Protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building* and ASTM D 1079. The definitions from the *Florida Building Code, Building* shall take precedence.

3.1.1 All references to "bearing plate" are interchangeable with "stress plate."

3.1.2 The dynamic pull-off value under dynamic eccentric loading shall be defined as the mean load capacity obtained at failure. Failure shall be defined as any of the following:

- breakage of the stress plate;
- pull through of the fastener head in the stress plate; or,
- permanent deformation of the fastener, fastener head or stress plate in excess of $^1/_4$ inch (6.3 mm).

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 The test procedure provides a means of determining of the dynamic pull-off performance of roofing fastener assemblies when exposed to dynamic eccentric loading.

4.2 The test procedure is acceptable for all types of fasteners with integral bearing plates and fasteners with separate bearing plates.

Note: Roofing nails or cap nails are not approved for use within the high-velocity hurricane zone jurisdiction. therefore, results from testing these nail types shall not be utilized as design values for projects within this jurisdiction. In addition, the minimum and maximum bearing plate diameters for anchor or base sheet attachment within the high-velocity hurricane zone jurisdiction are $1^5/_8$ inches (41 mm) and 2 inches (51 mm), respectively. Therefore, results from testing bearing plates having a diameter less than $1^5/_8$ inches (41 mm) or greater than 2 inches (51 mm) shall not be utilized as design values for projects within this jurisdiction.

5. Sampling:

5.1 Fastener and/or bearing plate samples shall be provided directly from the respective manufacturer and shall be tested as delivered. Unless otherwise specified, 14 samples shall be tested for each variable in the test specimen (i.e. different fastener or different bearing plate).

6. Test Method:

6.1 General:

6.1.1 The dynamic pull-off value is determined by subjecting the test specimen to a dynamic eccentric loading.

6.2 Apparatus

6.2.1 The test apparatus is shown in Figures 1, 4 and 5, attached.

6.2.2 A wire reinforced test strap (See Figures 2 and 3, attached). The test strap shall consist of a 0.08 inch (2 mm) diameter steel wire welded between two plys of 0.05 inch (1.2 mm) PVC membrane reinforced with polyester fabric. At the point of contact in the wire loop, an additional ply of membrane shall be wrapped around the wire to avoid cutting action on the fastener.

6.2.3 Attachment cables having varying lengths for various drop heights.

6.2.4 Drop weights having a mass of 5 pounds (2.3 kg).

6.2.5 A device to measure, reference and mark the height of drop.

6.3 Preparation of test samples:

6.3.1 The fasteners shall not be prepared in any way; however, care shall be taken to insure that fasteners are mounted in the test specimen in a defined, consistent manner.

6.3.2 The fastener assembly sample shall be installed through the center of the test apparatus as shown in Figure 1, attached.

6.3.3 Dynamic pull-through testing shall be conducted in a room with controlled temperature and humidity, 73°F (23 ± 2°C) and RH 50 percent.

6.4 Procedure:

6.4.1 The fastener assembly test specimen shall be mounted in the test apparatus to insure no fastener withdrawal will occur upon loading.

6.4.2 The dynamic load shall be applied as follows:

- *Fixed drop height:*
  The fastener assembly shall be subjected to a dynamic impact load with the drop weight being released from a fixed drop height to the nearest 1 inch.
- *Intervals of increasing drop heights:*
  The fastener assembly shall be subjected to dynamic impact loads of increasing intensity with the drop weight being released from increasing drop heights at intervals of 3 inches (100 mm) until failure occurs.

Application of a dynamic impact load from a fixed drop height shall only be considered if the fastener assembly has previously been tested and the intent is to upgrade the fastener assembly pull-off value. The datum point of drop height shall then be the previous test result.

6.5 Interpretation of results:

6.5.1 Table 1 below lists the corresponding fastener assembly pull-off values which relate to respective drop heights. These values shall be recorded upon completion of testing and shall be statistically analyzed, as noted in Section 6.6, herein.

TABLE 1
FASTENER ASSEMBLY PULL-OFF VALUES VS. DROP HEIGHT

Drop Height (ft)	Pull-Off Value (lbf)
4	20
5	25
6	30
7	35
8	40
9	45
10	50
11	55
12	60
13	65
14	70

For SI: 1 foot = 304.8 mm.

6.6 Statistical analysis of results:

6.6.1 Eliminate the 'high' and 'low' values recorded during the dynamic pull-off testing and calculate a mean and a standard deviation from the remaining 12 recorded values using the following equations.

$$\overline{F} = \frac{1}{12}\sum_{i=1}^{12} F_i$$

$$S_F = \sqrt{\frac{1}{11}\sum_{i=1}^{12}\left(F_i - \overline{F}\right)^2}$$

where,

$\overline{F}$ = mean load;

S_F = standard deviation;

F = record load; and,

i = test number

6.6.2 Determine the percent deviation from the mean (S'_F) using the following equation.

$$S'_F = \left(\frac{S_F}{F}\right) \times 100$$

If the percent deviation from the mean (S'_F) is greater than 35 percent, then the test results shall be considered null and void and the dynamic pull-off performance under dynamic eccentric loading shall be retested.

7. Report:

7.1 The final test report shall include the following relevant information:

7.1.1 Name and address of the testing laboratory.

7.1.2 Identification number of the test report.

7.1.3 Name and address of the organization or the person who ordered the test.

7.1.4 Purpose of the test.

7.1.5 Method of sampling and other circumstances (date and person responsible for the sampling).

7.1.6 Name and address of manufacturer or supplier of the tested object(s).

7.1.7 Name or other identification marks of the tested object(s).

7.1.8 Description of the tested object(s).

7.1.9 Date of supply of the tested object(s).

7.1.10 Date of the test.

7.1.11 Test method.

7.1.12 Conditioning of the test specimens, environmental data during the test (temperature, pressure, RH, etc.).

7.1.13 Identification of the test equipment and instruments used.

7.1.14 Any deviations from the test method.

7.1.15 Test results and statistical analysis computations.

7.1.16 Date and signature.

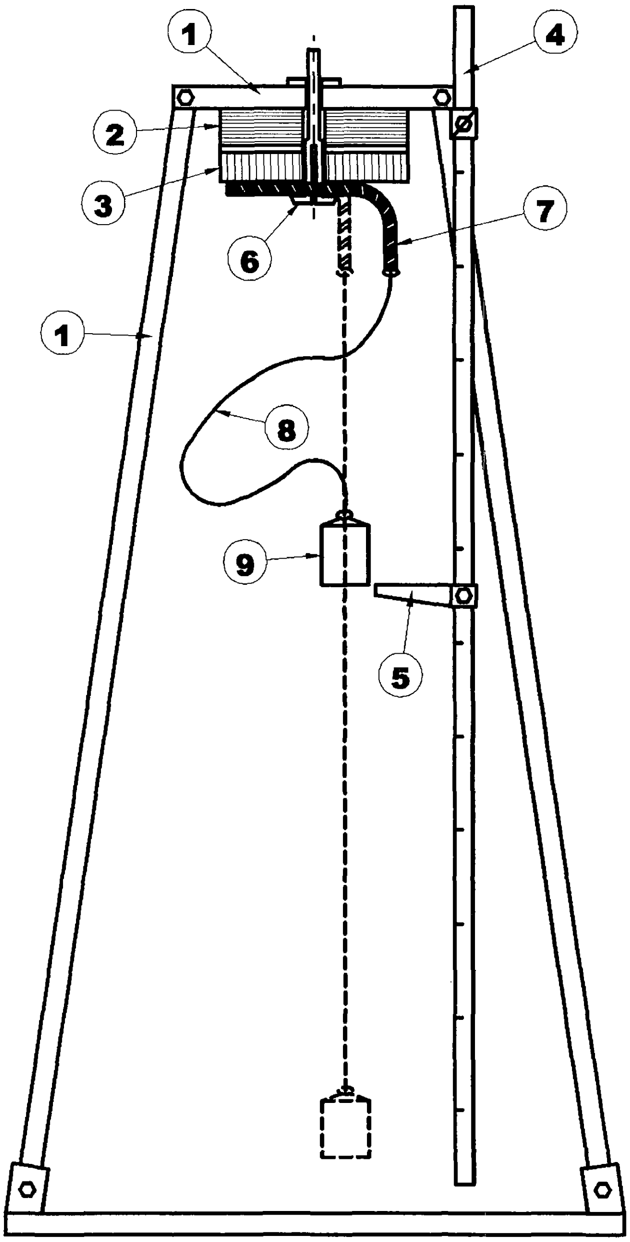


FIGURE 1
DIAGRAM OF DYNAMIC PULL-OFF TEST APPARATUS

1. Steel Frame
2. $1^3/_4$-inch (45 mm) rubber pad
3. 2-inch (50 mm) wood plank
4. Drop height measurement device
5. Drop height reference indicator
6. Fastener assembly test specimen
7. Test strap
8. Steel wire of appropriate length
9. Drop weight

For SI: 1 inch = 25.4 mm.

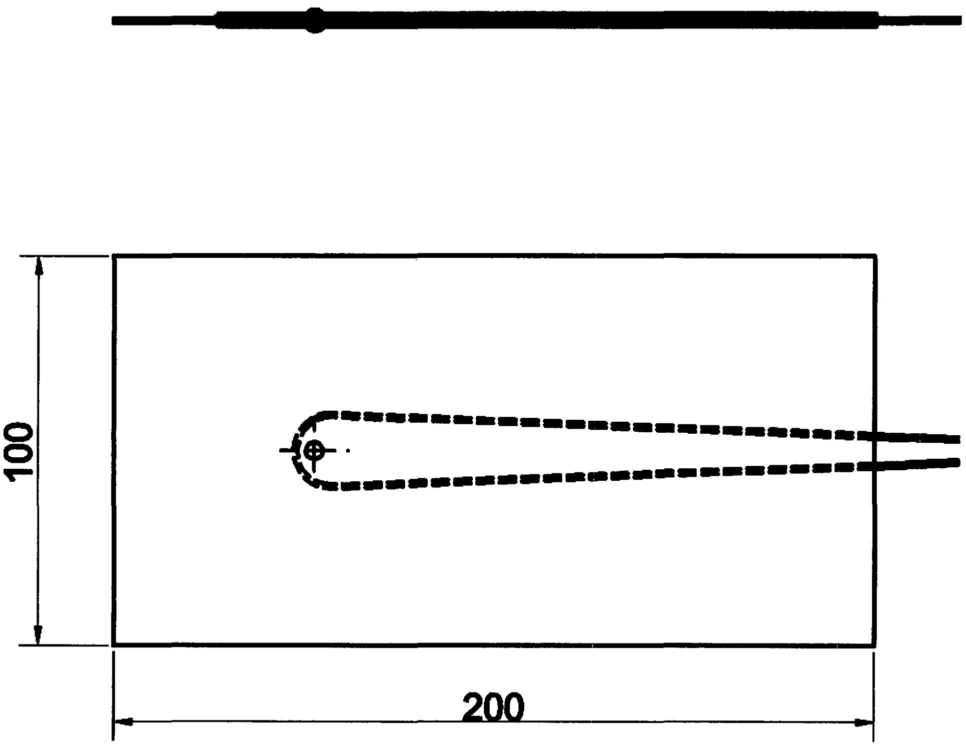


FIGURE 2
DIAGRAM OF WIRE REINFORCED TEST STRAP

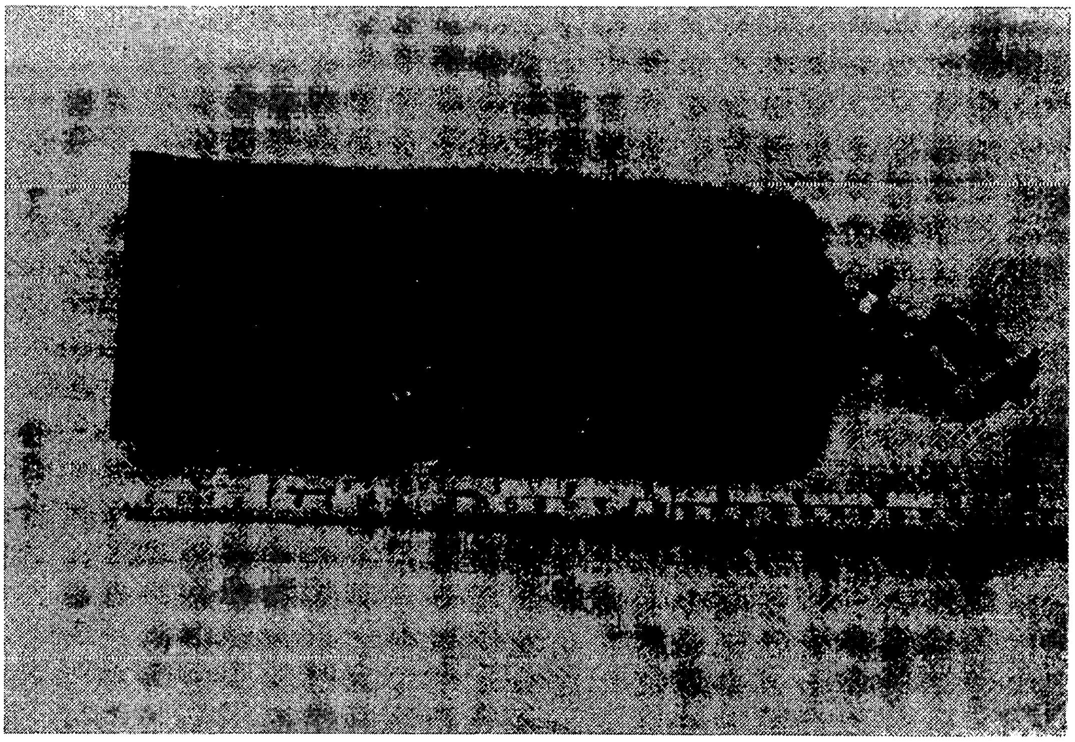


FIGURE 3
PHOTOGRAPH OF TYPICAL WIRE REINFORCED TEST STRAP

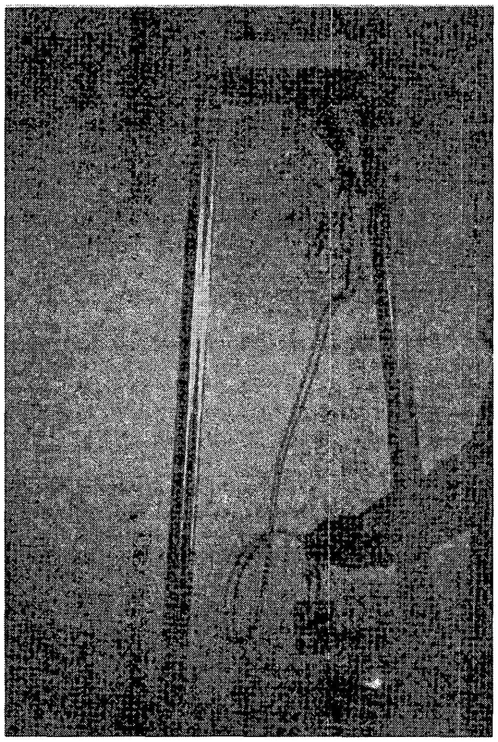


FIGURE 4
PHOTOGRAPH OF DYNAMIC PULL-OFF TESTING

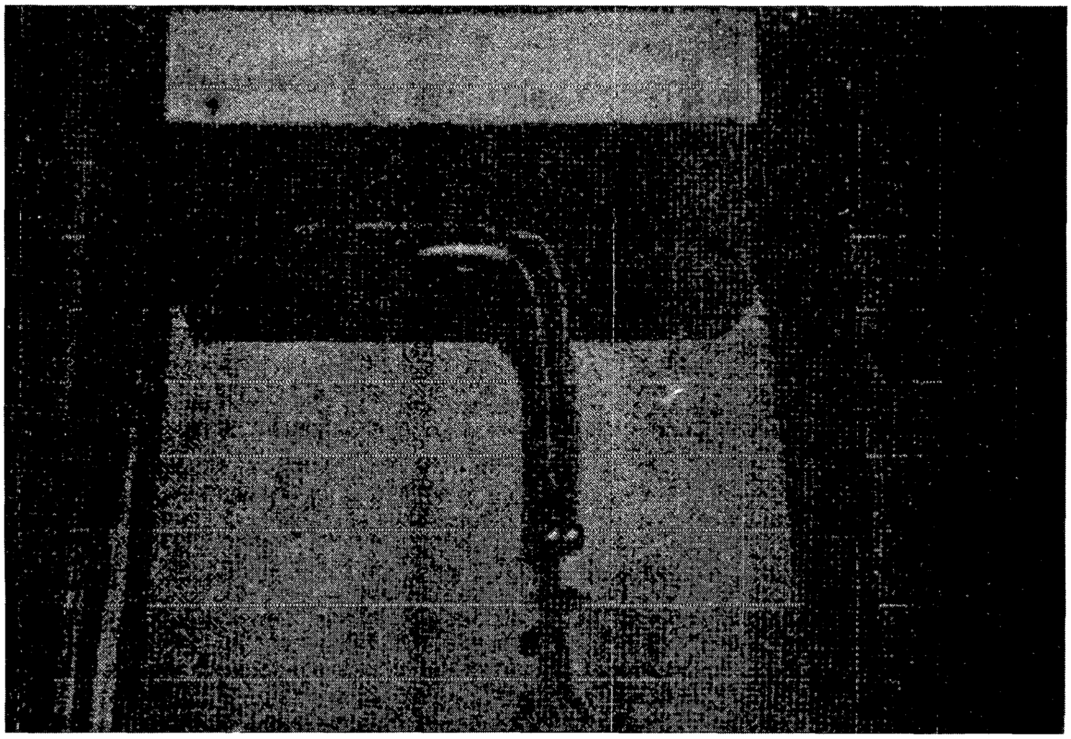


FIGURE 5
PHOTOGRAPH OF DYNAMIC PULL-OFF TESTING

TESTING APPLICATION STANDARD (TAS) 121-95

STANDARD REQUIREMENTS FOR TESTING AND APPROVAL OF ROOFING ADHESIVES, MASTICS AND COATINGS

1. Scope:

1.1 This protocol cover the procedures for testing of adhesives, mastics and coatings used in roofing applications and the approval process for all products which have successfully met the testing criteria.

1.2 This protocol applies to all products used in both low and steep slope roofing applications, other than sealants (See TAS 132 for sealant requirements).

1.3 All testing shall be conducted by an approved testing agency, which provides a listing service. All test reports shall be executed by a professional engineer and an authorized signatory of the testing/listing agency.

1.4 This protocol establishes the testing and listing program required of these products to confirm continuing compliance with the ASTM or Testing Application Standards.

1.5 This protocol has not been contemplated to measure the performance of the adhesives, mastics and coatings in conjunction with all approved roof system assemblies.

2. Referenced Documents:

2.1 *The Florida Building Code, Building.*

2.2 *ASTM Standards:*

D 140	Standard Practice for Sampling Bituminous Materials
C 1021	Standard Practice for Laboratories Engaged in the Testing of Building Sealants
D 1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.3 *Application Standards*

TAS 110	Testing Requirements for Physical Properties of Roof Membranes, Insulation Coatings and Other Roofing Components.

2.4 *Roof Consultants Institute:* Glossary of Terms

3. Terminology:

3.1 Definitions –For definitions of terms used in this Protocol, refer to ASTM D 16; and/or ASTM D 1079 and/or Chapter 2 of the *Florida Building Code, Building*; and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Test Specimens:

4.1 Sampling of all bituminous products under this Protocol shall be in compliance with ASTM D 140.

4.2 Unless otherwise noted in the specific ASTM Test Standard, sampling of all non-bituminous products under this protocol shall be in compliance with ASTM C 1021. Particular reference is made to Subsection 5.2.1 of this test standard.

5. Listing Services:

5.1 All products which require testing shall be tested by an approved testing agency which provides an annual listing service.

5.2 All products shall be listed in the testing agency's annual directory and shall be subject to unannounced manufacturing audits to insure compliance with manufacturing guidelines.

6. Testing Requirements:

6.1 All products noted herein which successfully obtain Product Approval shall have been tested in compliance with all applicable ASTM or Testing Application Standards enumerated in TAS 110.

6.2 All applicable test data and test reports shall be submitted with the roofing component manufacturer's application for Product Approval.

6.3 When a roofing component Product Approval is attained, the approved product shall have its Product Approval number imprinted on it or its packaging, along with the approved testing/listing agency's name and logo, as noted in Section 6.3, herein.

7. Packaged Material:

7.1 Packaged material shall be certified by the manufacturer to be in compliance with this specification and shall be labeled in compliance with Section 1517 of the *Florida Building Code, Building*. Product Approval documents shall be provided to the purchaser or end user upon request.

7.2 Shipping containers shall be marked with the name of the material, stock number, lot number, year of issue and quantity therein and the name of the manufacturer or supplier.

8. Rejection and Reinspection

8.1 The authority having jurisdiction may periodically purchase commercial quantities of the approved product for testing at approved Testing Agencies to confirm compliance with the provisions of the ASTM Standard or Testing Application Standards. Failure to meet the minimum physical property and performance properties of the test standard shall constitute grounds for rejection of the lots and suspension of the Product Approval. In cases of rejection the chief code compliance officer shall request removal of the rejected lot number(s) from commercial sale.

8.2 The chief code compliance officer may, after rejection of one or more lots, require third party quality control inspection as a provision to lifting of approval suspension.

TESTING APPLICATION STANDARD (TAS) 123-95

STANDARD REQUIREMENTS FOR MORTAR USED IN MORTAR SET TILE SYSTEMS

1. Scope:

1.1 This protocol covers: 1) the standard requirements of mortar for use in mortar set tile systems; 2) the procedures for testing such mortar if these standards are not initially met; and, 3) the approval process for all mortar which successfully meets either the standard requirements and/or the testing requirements.

1.2 This protocol applies to all mortar which is intended for use in Product Approved mortar set tile systems within the high-velocity hurricane zone jurisdiction.

1.3 All testing shall be conducted by an approved testing agency and all test reports shall be signed by an authorized signer of the testing agency and/or professional engineer.

2. Referenced Documents:

2.1 *The Florida Building Code, Building*

2.2 *ASTM Standards:*

C 270	Standard Specification for Mortar for Unit Masonry
C 91	Standard Specification for Masonry Cement
C 144	Standard Specification for Aggregate for Masonry Mortar
C 109	Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or 50-mm Cube Specimens)
E 380	Excerpts from Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.3 *Application Standards:*

TAS 101	Test Method for Static Uplift Test Resistance of Mortar or Adhesive Set Tile Systems

3. Terminology & Units:

3.1 Definitions–For definitions of terms used in this Protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building*; and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units–For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 The requirements outlined herein are intended to provide a guideline for mortar manufacturers in order to obtain a Roofing Component Product Approval for use of their product(s) in approved mortar set tile systems.

5. Standard Requirements for Approval:

5.1 Mortars for use in mortar set tile systems shall meet the 'Proportion Requirements' and 'Property Specifications' set forth in ASTM C 270 for type 'M' masonry cement mortar which is premixed and bagged. The sand: masonry cement mixing ratio shall not be exceed 2.5:1.

5.2 Alternatively, mortars for use in mortar set tile systems shall consist of not greater than $2^1/_2$ parts ASTM C 144 uniformly graded sand or $2^1/_2$ parts ASTM C 332 lightweight aggregate in combination with one part ASTM C 91, type 'M' masonry cement which is premixed and bagged.

5.2.1 Mortars formulated as noted in Section 5.2 using lightweight aggregate are not required to meet the minimum compressive strength of those mortars from Section 5.1; however, the compressive strength shall be not less than 350 psi, as determined in compliance with ASTM C 109.

5.3 All mortars which meet the standard requirements set forth in Sections 5.1 or 5.2 shall be approved for use with flat tile profiles only based on submission of the following:

- completed application for roofing component Product Approval;
- certification from an approved testing agency that the mortars, or components thereof, meet the requirements set forth in Sections 5.1 or 5.2, respectively;
- street address where periodic quality control inspections may be carried out by a representative from the authority having jurisdiction;
- a sample of the premixed bag; and,
- a copy of the handling and mixing instructions.

5.4 Any mortars which deviate from the standard requirements set forth in Sections 5.1 or 5.2, either through differing proportions or a substitution of masonry cement, sand or lightweight aggregate, and any mortars intended for use with low and high profile tile shall be tested as set forth in Section 6 prior to receiving roofing component Product Approval.

5.4.1 Mortars which require testing, as noted in Section 5.2, and use lightweight aggregate as a component thereof are not required to meet the minimum compressive strength of those mortars from Section 5.1; however, the compressive strength shall be not less than 350 psi, as determined in compliance with ASTM C 109.

6. Testing Requirements:

6.1 Any mortars which deviate from the standard requirements set forth in Sections 5.1 or 5.2, either through differing proportions or a substitution of masonry cement, sand or lightweight aggregate, and any mortars intended for use with low or high profile tile shall be tested in compliance with TAS 101 with the following modifications:

6.1.1 Testing shall include 5 samples each desired tile profile.

6.1.2 The static uplift testing shall result in the following minimum characteristic resistance loads (F′).

Tile Type	Minimum Characteristic Resistance Load (lbf)
High Profile	30
Low Profile	26
Flat	50

6.1.3 The moment calculations shall be omitted from the requirements of TAS 101.

6.2 On successful completion of this testing, the manufacturer shall submit the applicable items listed in Section 5.3, together with the final test report(s), from TAS 101 testing, to receive a roofing component Product Approval.

7. Mortar Set Tile System Manufacturers:

7.1 Mortar set tile system manufacturers may interchange any approved, premixed, bagged mortar product into mortar set tile system(s).

TESTING APPLICATION STANDARD (TAS) 123-95
APPENDIX A

STANDARD REQUIREMENTS OF TILE ADHESIVE USED TO REPAIR OR SUPPLEMENT TILE ATTACHMENT

1. Scope:

1.1 This protocol covers the testing requirements for tile adhesive applied to Product Approved nail-on, mortar set or adhesive set tile systems.

1.2 All testing shall be conducted by an approved testing agency and all test reports shall be signed by an authorized signer of the testing agency and/or professional engineer.

2. Referenced Documents:

2.1 *ASTM Standards:*

C 661	Standard Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer
C 1021	Standard Practice for Laboratories Engaged in the Testing of Building Sealants
D 95	Standard Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D 412	Standard Test Method for Rubber Properties in Tension
D 572	Standard Test Method for Rubber Deterioration by Heat and Oxygen
D 897	Standard Test Method for Tensile Properties of Adhesive Bonds
D 1079	Standard Definitions of Terms Relating to Roofing, Waterproofing, and Bituminous Materials
D 2565	Operating Xenon Arc-type Night Exposure Apparatus With and Without Water for Exposure of Plastics
E 380	Excerpts from Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.2 *Application Standards:*

TAS 101	Test Procedure for Static Uplift Resistance of Mortar or Adhesive Set Tile Systems
TAS 102	Test Procedure for Static Uplift Resistance of Mechanically Attached, Rigid, Roof Systems

2.3 *Roof Consultants Institute*
Glossary of Terms

3. Terminology and Units:

3.1 Definitions—For definitions of terms used in this Protocol, refer to ASTM D 16; and/or ASTM D 1079; and/or Chapter 2 of the *Florida Building Code, Building*; and/or The RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 This protocol appendix applies only to tile adhesives used in tile systems as a:

- repair component for mortar or adhesive set tile applications; or,
- supplement to the attachment in a nail-on tile application.

5. Test Limitations and Precautions:

5.1 The protocol may involve hazardous materials, operations and equipment. This protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

6. Materials and Manufacture:

6.1 Tile adhesive used for the purposes of tile repair or supplemental attachment shall consist of a synthetic rubber and resins or such other base component material that will comply with the undernoted performance and physical characteristics.

6.2 Colors shall be tan, terra-cotta, gray or such other color which blends with tile coloring.

7. Sampling:

7.1 Sampling shall be in compliance with requirements set forth in ASTM C 1021. Particular reference is made to Subsection 5.2.1 of the procedure.

8. Performance Testing & Requirements:

8.1 Composition:

8.1.1 Water content–Tile adhesive shall meet the maximum water volume percentage noted in Table 1, below, when tested in compliance with Section 9 of ASTM D 95.

8.1.2 Nonvolatile matter –Tile adhesive shall meet the minimum nonvolatile matter mass percentage noted in Table 1, below, when tested in compliance with ASTM D 2369.

TABLE 1
TILE ADHESIVE COMPOSITION REQUIREMENTS

Component	Criteria	Value
Water	Volume %	Maximum 1.5%
Nonvolatile Matter	Mass %	Minimum 65% + 5%

8.2 Uniformity–A thoroughly blended sample of tile adhesive shall show no separation of material after standing for 72 hours at room temperature (73.3° ± 3.6° F) in a closed container.

8.3 Workability –The tile adhesive shall be of such a consistency that it is easily forced from a tube with a $^{1}/_{4}$ inch diameter hole with a hand held caulk gun at temperatures ranging from 40°F (4°C) to 100°F (38°C).

8.4 Adhesion–Tile adhesive shall meet the minimum adhesion requirements noted in Table 2, below, when tested in compliance with ASTM D 897.

TABLE 2
TILE ADHESIVE ADHESION REQUIREMENTS

Bonded Component Interface	Conditioning	
	3000 hours @ 72°F (22.2 °C)	3000 hours @ 180°F (82.2 °C)
Concrete to Mortar	65 psi	35 psi
Concrete to Concrete	100 psi	143 psi
Concrete to Wood	85 psi	70 psi
Clay to Clay	128 psi	128 psi
Slate to Slate	112 psi	199 psi

8.5 Tensile/elongation–Tile adhesive shall meet the minimum requirements noted in Table 3, below, when tested in compliance with ASTM D 412.

TABLE 3
TILE ADHESIVE TENSILE/ELONGATION REQUIREMENTS

Physical Property	Conditioning	
	3000 hours @ 72°F (22.2 °C)	1000 hours @ 158°F (70.0 °C)
Tensile Strength	1000 psi	1200 psi
Elongation	400%	370%
Modulus	700 psi	NA

8.6 Static uplift resistance–Tile adhesive shall be tested for resistance to static uplift loading in compliance with TAS 102, except as noted below.

8.6.1 Test specimen:

- The test specimen shall include high profile, concrete "S-shaped" tiles mechanically attached directly to the deck with a single 8d annular ring shank nail.

- Tile adhesive shall be applied at the 'test tile' headlap in a single $^3/_8$ inch wide by $1^1/_4$ inch long bead placed between $1\ ^1/_2$ inches and 2 inches from the nose of the 'test tile.'
- The test specimen shall be conditioned as specified in Section 8 of TAS 101.

8.6.2 Calculations:

- Calculations need not include those for restoring moment due to gravity or attachment resistance expressed as a moment.

8.6.3 Requirement:

- The tile attachment, when installed in compliance with Section 8.6.1, shall provide a minimum characteristic resistance load (F') not less than 35 lbf.

8.7 Shore 'A' hardness - Tile adhesive shall meet the minimum requirements noted in Table 4, below, when tested in compliance with ASTM C 661.

TABLE 4
SHORE 'A' HARDNESS REQUIREMENTS

Conditioning	Hardness	Flexibility
Unconditioned	80 + 5	flexible
4 months @ 158°F (70°C) 1000 hours of UV Exposure *(ASTM D 2565)*	80 +7 80 +7	flexible flexible
1000 hours O_2 Bomb @ 158°F (70°C) *(ASTM D 572)*	80 +7	flexible
2000 hours O_2 Bomb @ 158°F (70°C) *(ASTM D 572)*	80 +7	semi-flexible

9. Packaged Material:

9.1 Packaged material shall be certified by the manufacturer to be in compliance with the provisions of this protocol and shall be labeled in compliance with Section 1517 of the *Florida Building Code, Building*. Product Approval documents shall be provided to the purchaser or end user upon request.

9.2 Shipping containers shall be marked with the name of the material, stock number, lot number, year of issue and quantity therein and the name of the manufacturer or supplier.

10. Rejection and Reinspection:

10.1 The chief code compliance officer may periodically purchase commercial quantities of the Approved product for testing to confirm compliance with the provisions of this protocol. Failure to meet the minimum requirements set forth in this protocol shall constitute grounds for rejection of the lots and suspension of the Product Approval. In cases of rejection the code compliance officer shall request removal of the rejected lot number(s) from commercial sale.

10.2 The code compliance officer may, after rejection of one or more lots, require third party quality control inspection as a provision to lifting of approval suspension.

TESTING APPLICATION STANDARD (TAS) 124-95

TEST PROCEDURE FOR FIELD UPLIFT RESISTANCE OF EXISTING MEMBRANE ROOF SYSTEMS AND IN SITU TESTING FOR REROOF AND NEW CONSTRUCTION APPLICATIONS

1. Scope:

1.1 This protocol covers the determination of the resistance to uplift pressure of newly installed, adhered, built-up, bituminous roofing systems over mechanically attached or adhered rigid board insulation over various deck types.

1.2 The test procedures outlined herein are intended to determine the performance of a new roof system assembly when installed over an existing roof system assembly or directly over a roofing substrate.

1.3 The test procedures outlined herein are intended to determine whether the uplift resistance performance of a newly installed Roof System Assembly meets the design pressure requirements of ASCE 7, as required in Section 1606 of the *Florida Building Code, Building*. The design pressure requirements for the building in question are listed on Section II of the Uniform Building Permit.

1.4 Tests shall be conducted prior to full-scale test assemblies to ensure that the specific maximum pressures set forth in the built-up roofing manufacturer's Product Approval can be achieved utilizing the specified components (i.e., fasteners, insulation, etc.).

1.5 When insulation boards are mechanically attached or adhered to the deck, the test shall be conducted not less than 7 days after roofing work is complete. Systems containing cold adhesive shall be in place not less than 14 days prior to conducting the test.

1.6 All testing shall be conducted by an approved testing agency and all test reports shall be signed by a professional engineer or registered roof consultant.

2. Referenced Documents:

2.1 *ASTM Standards*

D 41	Standard Specification for Asphalt Primer used in Roofing, Damp proofing, and water proofing
D 1079	Definitions and Terms Related to Roofing, Waterproofing and Bituminous Materials
E 380	Excerpts from Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)
E 575	Practice for Reporting Data from Structural Tests of Building Constructions, Elements, Connections and Assemblies.
E 907	Test Method for Field Testing Uplift Resistance of Roofing Systems Employing Steel Deck, Rigid Insulation and Bituminous Built-Up Roofing

2.2 *Factory Mutual Engineering Corporation:*
Loss Prevention Data Sheet 1-28(S), November, 1991
Loss Prevention Data Sheet 1-49, June, 1985
Loss Prevention Data Sheet 1-52, February, 1986

2.3 *National Roofing Contractors Association:*
NRCA/ARMA Manual of Roof Maintenance and Repair
NRCA Roofing and Waterproofing Manual

2.4 *The Florida Building Code, Building:*
Chapter 16 (High-Velocity Hurricane Zones) Design Loads
Chapter 19 (High-Velocity Hurricane Zones)

Reinforced Gypsum Concrete and Insulating Concrete
Chapter 21 (High-Velocity Hurricane Zones) Masonry
Chapter 22 (High-Velocity Hurricane Zones) Steel and Iron
Chapter 23 (High-Velocity Hurricane Zones) Wood
Chapter 15 (High-Velocity Hurricane Zones) Roof Covering and Application

2.5 *Application Standards:*

TAS 105	Test Procedure for Field Withdrawal Resistance Testing
TAS 114	Test Procedures for Roof System Assemblies in the High-Velocity Hurricane Zone Jurisdiction

2.6 *Application Standards:*

RAS 111	Standard Requirements for Attachment of Perimeter Woodblocking and Perimeter Flashing
RAS 117	Standard Requirements for Bonding or Mechanical Attachment of Insulation Panels to and Mechanical Attachment of Anchor or Base Sheets to Various Substrates

2.7 *Roof Consultants Institute:*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions–For definitions of terms used in this Protocol, refer ASTM D 1079; Chapter 2 and Section 1513 of the *Florida Building Code; Building* and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units –For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 The field test procedures specified herein provide a means for determining the uplift resistance of a new, adhered, built-up, bituminous roof system assembly, as stated in applicable specification bid documents, installed on a building within the high-velocity hurricane zone. The test procedures are intended to confirm and supplement the uplift resistance performance of roofing systems as determined under laboratory conditions and confirm that a given installation meets the design pressure requirements under ASCE 7, as required in Section 1606 of the *Florida Building Code, Building*.

4.1.1 Field testing of an assembly may be used to support the uplift resistance performance of a specific roof system assembly when the required number of samples noted in Section 7.1 and 7.2 have been tested, and averaged. A margin of safety of 1.45:1 shall be applied to the sample average.

4.1.2 Laboratory conditions may enable uplift investigations to include:

- examination of the critical components and their orientation within the roof system assembly;
- examination of the roof system assembly's long-term uplift resistance; and,
- examination of the roof system assembly's uplift resistance from the dynamic affect of variable wind velocities.

4.2 A contractor licensed to install roofing in the high-velocity hurricane zone shall be present during all tests should roof repairs be necessary. Any roofing component damaged during testing shall be repaired immediately subsequent to test completion.

4.3 When new construction will require a tear off of the existing roof system assembly, areas of existing roofing shall be removed to deck level. Sample assemblies shall be applied including a lifting panel, as detailed in Section 5.2 when the bonded pull test procedure is utilized. Sample panels shall be covered and waterproofed with a membrane roof covering to return the existing assembly to a waterproof condition.

5. Apparatus:

5.1 Bell chamber tests:

5.1.1 Square Uplift Chamber

- The square pressure chamber shall be 60 + $^{1}/_{2}$ inch (1500 ± 15 mm) in size with a maximum height in the center of the bell of 18 inches.
- The chamber shall be of sufficient strength to withstand not less than 125 pounds per square feet without collapsing.

5.1.2 Pressure measurement device:

- The pressure within the square uplift chamber shall be measured with a manometer which is calibrated to indicate negative pressures in increments of 15 ± 0.5 pound foot per square foot (720 ± 20 Pa).

5.1.3 Vacuum pump:

- Negative pressures shall be created within the pressure chamber with a vacuum pump of sufficient capacity to create the negative pressures specified in Section 8.9.
- The vacuum pump shall also be equipped with controls to maintain a constant pressure at each test pressure increment, as noted in Section 8.9.

5.1.4 Dial indicator:

- Membrane deflections shall be measured using an analog dial indicator with a reset face graduated in units not greater than 0.002 inch (0.05 mm) and having a range not less than 2 inches (50 mm).
- The analog dial indicator shall be mounted at the center of a 2 inch by 2 inch (50 mm by 50 mm) aluminum (or material of equivalent stiffness) bar having a length of 60 inches (1500 mm). The bar shall be supported with support legs which clear the roof membrane by not less than 2 inches (50 mm).

5.2 Bonded pull test:

5.2.1 Load transfer device:

- The load transfer device shall consist of two pieces of 2 feet square, $^{7}/_{8}$ inch thick plywood fastened together using 12 each, 1$^{1}/_{4}$ inch long wood screws to form a 2 feet by 2 feet by 1$^{3}/_{4}$ inch panel. Screw placement shall be as noted in Figure 1, below.

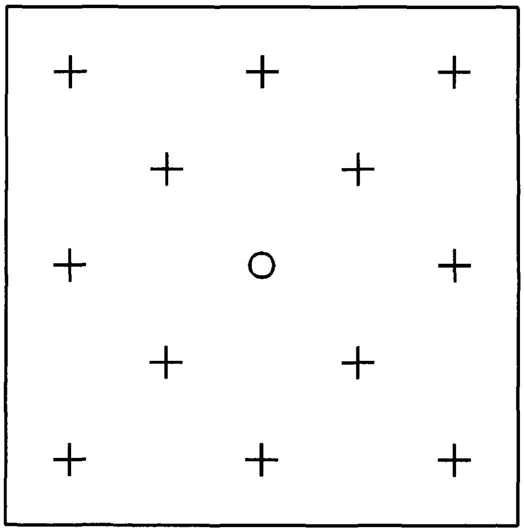


FIGURE 1
SCREW AND EYE-BOLT LOCATIONS

- Alternatively the top plywood panel may be substituted with a $^{3}/_{8}$ inch thick steel panel reinforced with two 2 inch sections of angle iron welded to the top face of the panel. The steel panel shall have $^{7}/_{16}$ inch diameter holes drilled at locations noted in Figure 1, above, through which $^{3}/_{8}$ inch countersunk machine screws shall be installed through the base of the plywood panel and secured to the steel plate with a washer and wing nut. (See Figure 2, below.)

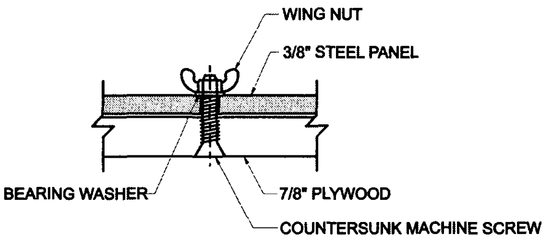


FIGURE 2
ALTERNATE LOAD TRANSFER DEVICE

- One $^1/_2$ inch diameter eye-bolt shall be installed in the center of the test panel and shall be secured to the underside with a lock nut and washers, as noted in Figure 1, above. Alternatively a ring shall be welded to the steel panel.
- A block and tackle or chain hoist shall be attached to the eye-bolt or welded ring with the opposite end attached to the top of a tripod, or equivalent support system, capable of withstanding a minimum of 1200 lbf downward load. The hoist assembly shall be capable of an incremental rise of $^1/_4$ inch.

5.2.2 Load cell:

- A load cell, or equivalent load measurement device, capable of recording loads up to 2000 lbf to an accuracy of 0.5 lbf, shall be attached between the hoist assembly and the eye-bolt or welded ring to measure the applied load.

6. Test Limitations and Precautions:

6.1 General:

6.1.1 Conduct tests when the roof's surface temperature is within a range of 40°F to 100°F (4°C to 38°C) as measured by a surface thermometer. The surface temperature shall be noted on the test report.

6.1.2 For safety considerations, it is recommended that tests not be conducted when the wind speed at the roof level is greater than 15 miles per hour (6.5 m/s). (A portable anemometer to measure wind speed may be utilized.)

6.1.3 Testing under this protocol shall not be conducted on mechanically attached roof system assemblies.

6.2 Bell chamber tests:

6.2.1 The manometer shall serve as a safety device to prevent negative pressures that could cause the plastic or fiberglass dome to shatter. The maximum negative pressure for the dome shall be clearly marked on the manometer. Alternatively other safety features shall be added to the test chamber to eliminate negative pressure greater than the design capabilities of the dome.

6.2.2 Safety goggles or face shield shall be worn by persons operating the equipment or observing its operation as a precaution against injury that could be caused by sudden failure of the test chamber or roofing system.

6.2.3 Care shall be taken to ensure that movement of persons and/or equipment during the test does not lead to movement of the analog dial indicator. During the test, all persons not involved shall stay far enough away from the test area to not influence the analog dial indicators.

6.3 Bonded pull test:

6.3.1 Testing shall only be conducted on fully adhered roof coverings.

6.3.2 Proper safety equipment shall be utilized and proper safety procedures followed during the application of hot asphalt or coal tar pitch.

Application of roofing products shall be in compliance with the safety guidelines published and recommended by the roof membrane manufacturer and by the National Roofing Contractors Association.

7. Sampling:

7.1 The total number of tests to be conducted when testing over an existing roof assembly is listed in Table 1, below. Of these tests, half shall be conducted at selected locations within the perimeter area of the roof and half shall be conducted at selected locations within the field area of the roof.

TABLE 1
NUMBER OF BELL CHAMBER OR BONDED PULL TESTS TO BE CONDUCTED PER ROOF AREA

Roof Area (A)	Number of Tests
10 squares < A < 50 squares (100 m^2 < A < 450 m^2)	2
50 squares < A < 100 squares (450 m^2 < A < 1000 m^2)	4
A > 100 squares (A > 1000 m^2)	4 plus 1 additional test for each additional 100 squares (1000 m^2) or portion thereof

[1] 1 square = 100 ft^2 = 9.3 m^2

7.2 Three test samples are required for all assemblies tested on any size roof deck when the test assembly is applied directly to the substrate for confirmation of design pressure performance. (See Section 4.1.1)

8. Acceptable Roof Deck Constructions:

8.1 Acceptable deck types for testing under this protocol are as follows:

- minimum $^{15}/_{32}$ inch plywood or wood plank;
- cementitious wood fiber;
- poured gypsum concrete;
- structural poured concrete;
- structural concrete plank;
- aggregate lightweight insulating concrete;
- cellular insulating lightweight concrete;
- aggregate/cellular insulating lightweight;
- 18-22 gage steel;
- > 22 gage steel; and,
- composite deck system (e.g. load master)

9. Procedure:

9.1 Bell chamber tests over an existing roof system assembly:

9.1.1 The test area's membrane surface shall be clean, smooth and dry to provide a continuous contact surface for the edges of the pressure chamber. For roof surfaces which contain surfacing such as gravel, slag or granules, the test areas shall be prepared as follows:

- Remove the loose gravel surfacing; sweeping a 12 inch (300 mm) wide square in which the chamber perimeter will be placed.
- Apply a heavy pouring of hot asphalt over the swept area and allow to completely cool.
- This test area preparation is intended to provide a continuous, smooth surface to which the edges of the test chamber make contact such that accurate pressure measurements are taken.

9.1.2 Place the bar with attached dial indicator such that the tip of the dial indicator is in contact with the roof membrane at the center of the test area.

9.1.3 Place the assembled chamber over the roof test area such that the bar with attached dial indicator is centered within the chamber and is perpendicular to the sides of the chamber. The edges of the chamber shall be in complete contact with the roof surface. Position the chamber such that its edges are parallel with the direction of the structural framing of the building.

9.1.4 Install the pressure measurement device to the uplift pressure chamber and calibrate to zero pressure.

9.1.5 Position the vacuum pump over the hole provided in the chamber, insuring that the bypass valve on the pump is open before starting the pump or, if a rheostat is used, that it is in the OFF position.

9.1.6 Raise the pressure within the chamber to 15 + 0.5 lbf/ft^2 (720 + 20 Pa) and hold this pressure level for one minute.

9.1.7 Continuously observe the deflection and pressure measurement device throughout the vacuum pumping process for sudden or variable rates of movement.

9.1.8 At the end of the first one minute interval, increase the pressure within the chamber in increments of 15 + 0.5 lbf/ft^2 (720 + 20 Pa), holding each pressure level for a period of one minute, until:

- the roof system assembly fails, as noted in Section 10.1;

or,

- the pressure within the chamber is held at the design pressure for the particular roof area (i.e., field, perimeter or corner area) for a period of one minute. These design pressures are determined in compliance with ASCE 7-98, as specified in Section 1606 of the *Florida Building Code, Building* and are listed on Section II of the Uniform Building Permit.

9.1.9 If 'failure,' as defined in Section 10.1, occurs, record the applied load and time.

9.2 Bell chamber test for a new roof system assembly applied directly to the substrate:

9.2.1 Remove the existing roofing membrane to the deck in an area of 8 feet by 8 feet, thoroughly cleaning the deck of all existing roofing material.

9.2.2 If the new assembly is to be adhered, prime the deck with ASTM D 41 primer and allow to completely dry.

9.2.3 Install the proposed roof system assembly utilizing the precise materials proposed for the reroof application. Install the test assemblies in strict compliance with published application recommendations.

9.2.4 Provide the testing agency with two copies of manufacturer's literature and application instructions.

9.2.5 Allow the test panel to cure for 48 hours if applied in hot asphalt or 28 days if solvent or waterbased adhesives are employed.

9.2.6 Do not apply aggregate surfacing to the test assembly. If an aggregate surface or coating is to be applied to the final assembly finish the test assembly with a flood coat of asphalt at an application rate of 384 pounds ± 10 pounds.

9.2.7 Seal the test assembly by strip flashing the test panel to the existing roof system assembly.

9.2.7.1 If the test assembly is lower than the existing roof system assembly the test assembly area shall be filled with a loose insulation material and the test area shall be covered for the cure period.

9.2.8 Testing of the panel shall be as noted in Section 9.1

9.3 Bonded pull test over existing roof system assemblies:

9.3.1 The test area's membrane surface shall be clean, smooth and dry to provide a continuous contact surface for test panel adhesion.

9.3.2 Cut an indentation in the center of the test area to accommodate the nut and washer on the underside of the test panel where a double plywood panel is used. Outline the test area perimeter, assign a reference number and photograph.

9.3.3 Suspend the wood or wood and steel test panel, with eye-bolt or welded ring installed, from the load application apparatus and record the downward load.

9.3.4 Apply a flood coat of hot steep asphalt or coal tar pitch over the marked test area at an application rate of 4 lb/ft^2 and float the test panel into place. Allow a curing time of 24 hours for hot asphalt and 48 hours for coal tar pitch applications. Curing time may vary due to atmospheric conditions.

9.3.4.1 Report any variation in cure time.

9.3.4.2 The flood coat application rate may be increased for unusual conditions to ensure a complete bond of the test assembly.

9.3.4.3 Report any variation in the adhesive application rate.

9.3.5 Determine the required uplift force (F) to be applied using information determined in Section 9.3.3 and the following equation:

$F = (4 \text{ by } P) + W$ where,

F = required uplift force (lbf);

P = design pressure (lbf/ft^2); and,

W = weight of test panel (lbf)

9.3.6 When the flood coat, noted in Section 9.3.4, has fully cured, cut a 2 inch to 3 inch wide strip through the roof covering around the test panel down to deck level. The intent is to fully isolate the test sample from surrounding roofing materials.

9.3.7 Position the support system over the test panel and attach the load application and measurement devices to the eye-bolt or welded ring.

9.3.8 Apply an initial load of 40 lbf plus the weight of the test panel (W + 40) and hold for 1 minute. After the initial 1 minute, increase the applied load by 40 lbf increments in 1 minute time intervals until the design pressure (P) is attained, as noted in Table 2, below.

TABLE 2
APPLIED LOAD INCREMENTS

Load (lbf)	Pressure (psf)	Hold Time (min)
W + 80	20	1
W + 120	30	1
W + 160	40	1
W + 200	50	1
F	P	1

9.3.9 If 'failure,' as defined in Section 10.2, occurs, record the applied load and time.

10. Interpretation of Results:

10.1 Bell chamber test:

10.1.1 Most roof system assemblies subjected to a negative pressure will exhibit an upward deflection that will increase as the negative pressure increases. Poorly adhered systems will exhibit relatively large increases in upward deflections with relatively small increases in applied pressure. For roof system assemblies that are well adhered, the increase in deflection will be gradual and at a relatively constant rate up to a point at or near failure. The upward deflection may slowly increase while maintaining the pressure within the chamber. When failure occurs due to lack of adhesive or cohesive resistance of the roof system assembly, there will be a sudden increase in the upward deflection, and most likely the deflection will exceed the capacity of the dial indicator.

10.1.2 Any roof system assembly which exhibits an upward deflection greater than or equal to 1 inch (25 mm) during any of the tests shall be considered as failing at the point where 1 inch (25 mm) of deflection is recorded.

10.1.3 An upward deflection in excess of $^1/_4$ inch (6 mm) or a sudden increase in deflection, as measured by the dial indicator, may indicate an attachment and/or adhesion problem in the roof system assembly and may require further investigation.

10.1.4 Upward deflection of the roof system assembly due to negative pressure may vary at different locations due to varying stiffness of the roof system assembly. Stiffness of a roof system assembly is influenced by the thickness of insulation; stiffness of decking; and by the type, proximity and rigidity of connections between the decking and framing system.

10.2 Bonded pull test:

10.2.1 Any roof system assembly which exhibits delamination of any portion of the test sample prior to the full 1 minute duration at an applied load equal to the design load (F) shall be considered as failing the bonded pull test.

10.2.2 If delamination occurs between the plywood test panel and the roof covering, the test panel shall be re-adhered to the test area, increasing the curing period of the hot steep asphalt coal tar pitch or such other adhesive material that may better adhere the test panel to the roof membrane.

11. Report:

11.1 Refer to ASTM E 575 for general use in reporting structural performance tests of building assemblies.

11.2 For either bell chamber tests or bonded pull tests, the final report shall include the following:

11.2.1 A copy of the roof system assembly manufacturer's Product Approval, indicating the maximum design pressure for the system, product data sheets and published application instructions.

11.2.2 A copy of Section II of the Uniform Building Permit for the project in question indicating design pressures for the field area, perimeter area, and if applicable, corner and extended corner areas of the structure.

11.2.3 The area, height, and plan view of the roof showing the location of the test areas, numbered to correspond with the test report.

11.2.4 A complete detailed description of the roof system assembly construction being tested. Include the type of steel roof deck and method of attachment, deck support spacing, vapor retarder and adhesive (if any), types and thicknesses of insulation and methods of attachment, and the type of adhered roof membrane including surfacing.

11.2.5 Dates of tests, air and roof surface temperatures, wind velocity.

11.2.6 Names, signatures and affiliations of all persons observing the tests.

11.2.7 Photographs documenting all pertinent aspects of the test, including test assembly construction, actual testing, failure examination (if applicable), and repair procedures (if applicable).

11.3 For bell chamber tests, the final report shall include the following:

11.3.1 A brief description of the test procedure, including the negative pressure increments, hold times for each pressure increment and the maximum applied pressure.

11.3.2 Tabulated results recorded at each pressure increment including observations and deflection measurements. Deflection shall be recorded at the start and end of each pressure increment.

11.3.3 If 'failure' occurs during any of the bell chamber tests, the test area shall be cut and thoroughly examined and the complete record should include:

- the negative pressure at which the failure occurred;
- the type of failure and its location within the roof system assembly; and,
- other observations of the roof system assembly conditions that may be attributed to the failure.

The cut area of roofing should be repaired after examination of the failed area or where roofing has been removed to deck level for the purpose of testing. Insulated assemblies shall be filled with like insulation prior to membrane repair.

11.3.4 The attached 'Bell Chamber Test Results' sheet completed in full. Make photocopies of the 'Data Recording Sheet' and indicate on each sheet the 'Level #' and the 'Test #.'

11.4 For bonded pull tests, the final report shall include the following:

11.4.1 A brief description of the test procedure, including the applied load increments, hold times for each load increment, the maximum applied load and the calculated maximum applied pressure.

11.4.2 Tabulated results recorded at each applied load increment including observations.

11.4.3 If 'failure' occurs during any of the bonded pull tests, the test area shall be cut and thoroughly examined and the complete record should include:

- the applied load and calculated applied pressure at which the failure occurred;
- the type of failure and its location within the roof system assembly; and,
- other observations of the roof system assembly conditions that may be attributed to the failure.

The cut area of roofing should be repaired after examination of the failed area or where roofing has been removed to deck level for the purpose of testing. Insulated assemblies shall be filled with like insulation prior to membrane repair.

11.4.4 The attached 'Bonded Pull Test Results' sheet completed in full. Make photocopies of the 'Data Recording Sheet' and indicate on each sheet the 'Level #' and the 'Test #.'

TESTING APPLICATION STANDARD (TAS) 124-95

BELL CHAMBER TEST RESULTS

GENERAL INFORMATION

Job Name: ________________________________

Job Address: ________________________________

____

Job Contact Person: ________________________________

TESTING AGENCY/EQUIPMENT INFORMATION:

Note: The undersigned representative agrees that all testing has been conducted and results have been reported in compliance with TAS 124.

Testing Agency Name: ________________________________

Address: ________________________________

Telephone: ( ) __________ __________

Fax: ( ) __________ __________

Representative Name: ________________________________

Title: ________________________________

Signature: ________________________________

Uplift Chamber (General Description):

____

____

____

BUILDING/ROOF SYSTEM INFORMATION:

Building Height:	height	=	____________ft
Building Dimensions:	length	=	____________ft
	second largest dimension	=	____________ft
	total roof area	=	____________ft^2
		=	____________sqs,

Deck Type: plywood or wood plank cementitious wood fiber

poured gypsum concrete aggregate l/w insulating concrete

structural poured concrete
structural concrete plank
18 - 22 ga. steel
composite (e.g. Load Master)

cellular l/w insulating concrete
aggregate/cellular insulating concrete
> 22 ga. steel

Insulation:
polyisocyanurate
glass fiber
cellular glass
extruded polystyrene
none

wood fiber
perlite
rockwool
expanded polystyrene
other: ____________________

combination: ___________ & ______________________________

Attachment:
mechanically attached (fasteners per ft^2)
in hot asphalt (lbs per square)
cold applied

Provide a brief description of the built-up roof system:

____

____

____

____

TEST INFORMATION:

Number of Tests: $n =$ ________
(see Section 7.1 of TAS 124)
(note the locations of all tests on
'Building Information' Detail #2, attached)

Maximum Uplift Pressure: $P_{max} =$ ________ psf
(as noted on the roof system manufacturer's Product Approval)

Design Pressures:

Level #1:
Field Area: P_{f1} = ________ psf
Perimeter Area: P_{p1} = ________ psf
Corner Areas: P_{c1} = ________ psf
Extended Corner: P_{ec1} = ________ psf

Design Pressures:

Level #2:
Field Area: P_{f2} = ________ psf
Perimeter Area: P_{p2} = ________ psf
Corner Areas: P_{cl2} = ________ psf
Extended Corner: P_{ec2} = ________ psf

Design Pressures:

Level #3:
Field Area: P_{ff3} = ________ psf
Perimeter Area: P_{p3} = ________ psf
Corner Areas: P_{c3} = ________ psf
Extended Corner: P_{ec3} = ________ psf

Note: If the number of levels on the building/project exceeds three (3), record design pressures for additional levels in a similar format.

DATA RECORDING SHEET: Level # ________

Bell Chamber Test Test # ________

Check the appropriate box for field, perimeter, corner or extended corner.

Field Area **Perimeter Area**

Corner Area **Extended Corner Area**

Uplift Pressure (psf)	Starting Deflection (inch)	Ending Deflection (inch)
15 psf	0.00"	________"
30 psf	______"	________"
________ psf	______"	________"
________ psf	______"	________"
________ psf	______"	________"
________ psf	______"	________"
________ psf	______"	________"
________ psf	______"	________"
________ psf	______"	________"

Check either 'pass' or 'fail:' pass fail

If the test resulted in failure, complete the following:

Suspected mode of failure: ____

____

____

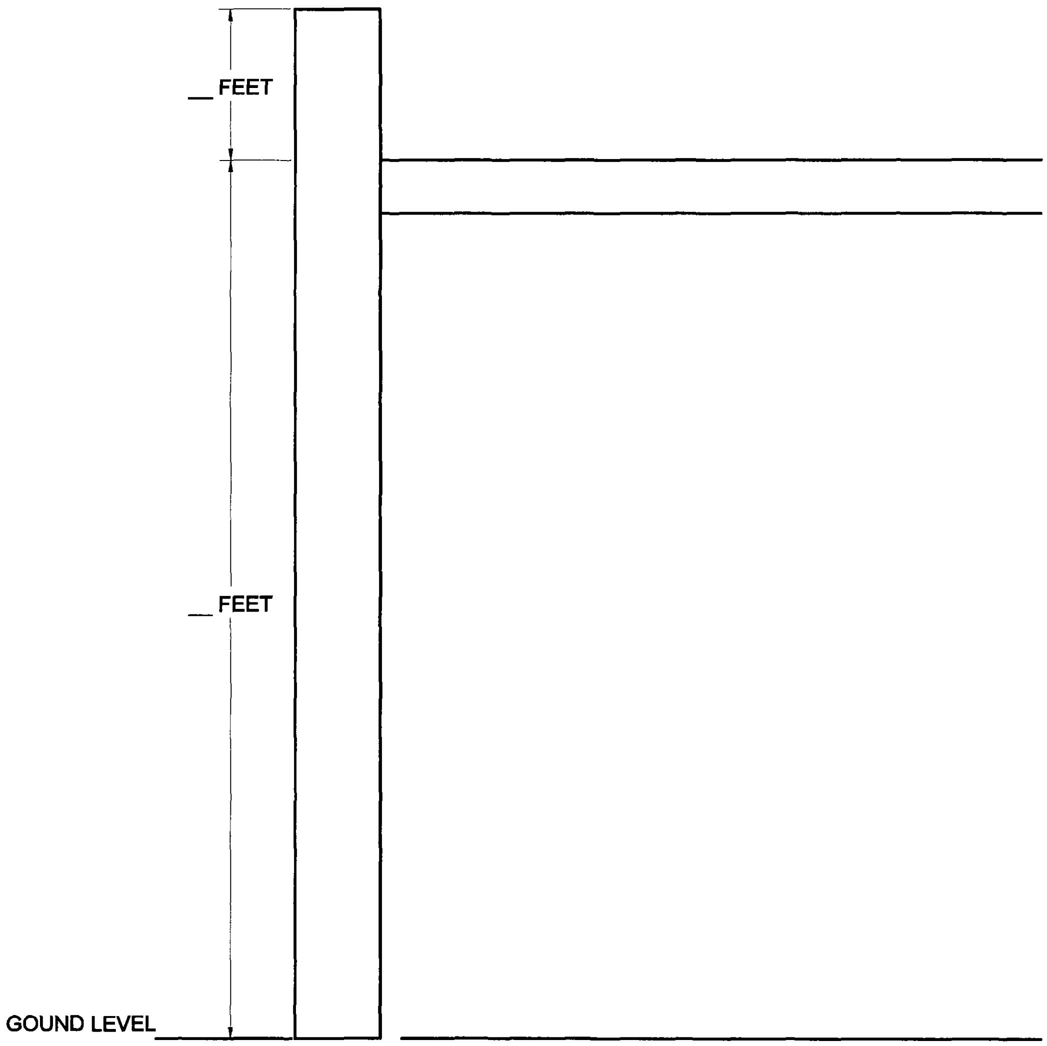
Was a test cut taken to confirm the mode of failure? yes no

____

____

Notes: **Provide one of these 'Data Recording Sheets' for each Bell Chamber Test conducted on each roof level. Multiple deck types shall be treated as separate roof levels. Stair towers, mechanical penthouses and mechanical rooms shall have a minimum of one (1) test conducted.**

INSERT BUILDING AND PARAPET HEIGHTS.
(IF NO PARAPET EXISTS, INSERT "N/A")

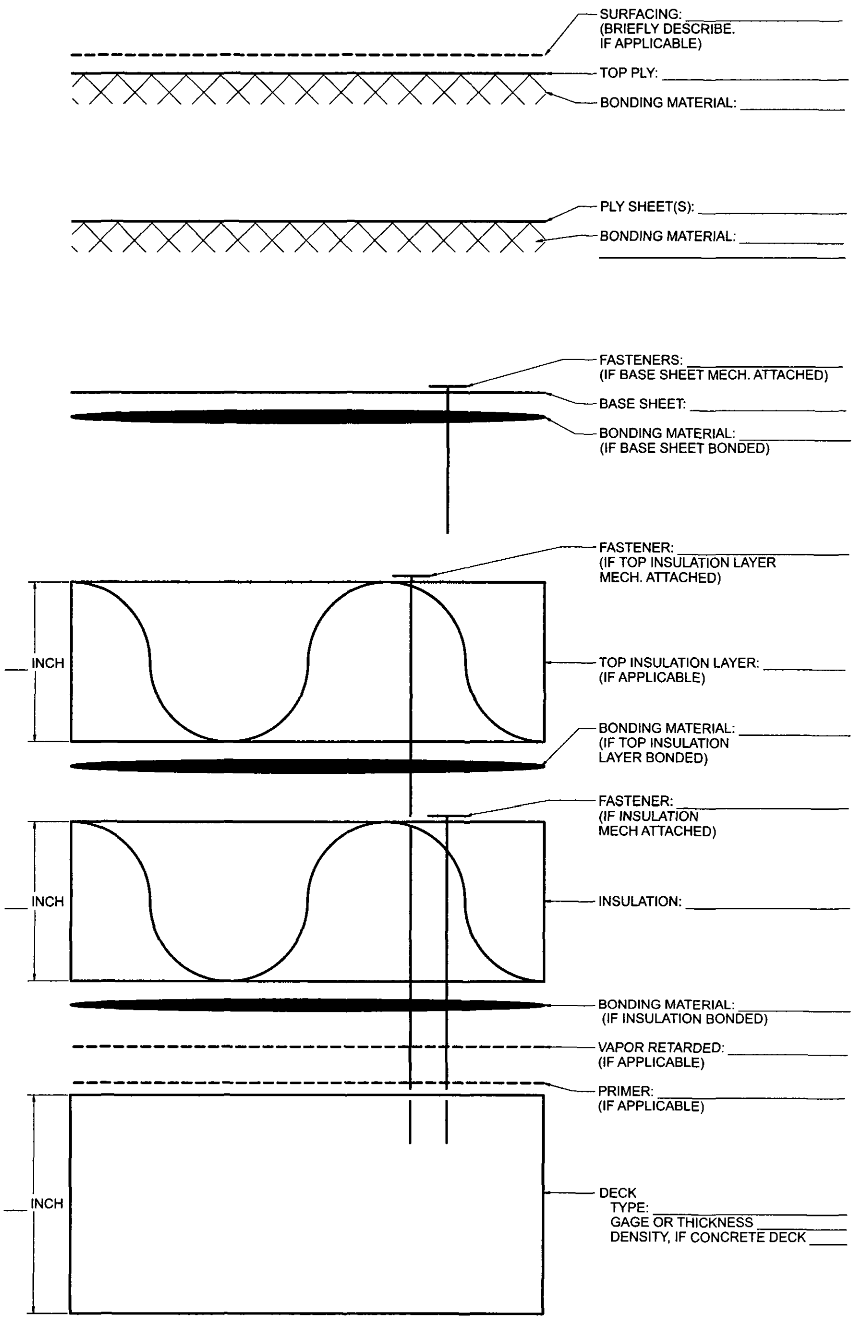


ROOF SYSTEM INFORMATION - DETAIL #1

BUILDING INFORMATION - DETAIL #2

SKETCH ROOF PLAN INDICATING ALL 'LEVEL #'S' AND THE LOCATION OF ALL TESTS CONDUCTED ON EACH LEVEL (i.e. 'T1', 'T2',....'Tn'). INCLUDE THE DIMENSIONS OF EACH LEVEL AND ANY ROOF DRAINS, SLOPES, AND/OR ROOF TOP EQUIPMENT WHICH EXISTS ON THE ROOF.

FILL IN EXISTING ROOFING COMPONENTS WHICH MAKE UP ROOF SYSTEM ASSEMBLY AND THICKNESS OF DECK AND INSULATION LAYER(S) (WHERE ROOFING COMPONENT NOT USED IN ROOF SYSTEM ASSEMBLY. FILL IN WITH "N/A")


SURFACING: ________________
(BRIEFLY DESCRIBE.
IF APPLICABLE)
TOP PLY: ________________
BONDING MATERIAL: ________
PLY SHEET(S): ____________
BONDING MATERIAL: ________
FASTENERS: ______________
(IF BASE SHEET MECH. ATTACHED)
BASE SHEET: ______________
BONDING MATERIAL: ________
(IF BASE SHEET BONDED)
FASTENER: _______________
(IF TOP INSULATION LAYER
MECH. ATTACHED)
__ INCH
TOP INSULATION LAYER: ______
(IF APPLICABLE)
BONDING MATERIAL: ________
(IF TOP INSULATION
LAYER BONDED)
FASTENER: _______________
(IF INSULATION
MECH ATTACHED)
__ INCH
INSULATION: ______________
BONDING MATERIAL: ________
(IF INSULATION BONDED)
VAPOR RETARDED: _________
(IF APPLICABLE)
PRIMER: _________________
(IF APPLICABLE)
__ INCH
DECK
TYPE: ________________
GAGE OR THICKNESS ________
DENSITY, IF CONCRETE DECK ____

ROOF SYSTEM INFORMATION - DETAIL #3

TESTED APPLICATION STANDARD (TAS) 124-95

BONDED PULL TEST RESULTS

GENERAL INFORMATION

Job Name: ____

Job Address: ____

____

Job Contact Person: ____

TESTING AGENCY/EQUIPMENT INFORMATION:

Note: The undersigned representative agrees that all testing has been conducted and results have been reported in compliance with TAS 124.

Testing Agency Name: ____

Address: ____

Telephone: (   ) __________ __________

Fax: (   ) __________ __________

Representative Name: ____

Title: ____

Signature: ____

Uplift Chamber (General Description):

____

____

____

BUILDING/ROOF SYSTEM INFORMATION:

Building Height: height = ____________________ft

Building Dimensions: length = ____________________ft

second largest dimension = ____________________ft

total roof area = ____________________ft^2

= ____________________sqs,

Deck Type:

plywood or wood plank

poured gypsum concrete

structural poured concrete

cementitious wood fiber

aggregate l/w insulating concrete

cellular l/w insulating concrete

	structural concrete plank	aggregate/cellular insulating concrete
	18 - 22 ga. steel	> 22 ga. steel
	composite (e.g. Load Master)	
Insulation:	polyisocyanurate	wood fiber
	glass fiber	perlite
	cellular glass	rockwool
	extruded polystyrene	expanded polystyrene
	none ____________	other: __________________________
	combination: ____________ &	__________________________
Attachment:	mechanically attached	(fasteners per ft^2)
	in hot asphalt	(lbs per square)
	cold applied	

Provide a brief description of the built-up roof system:

TEST INFORMATION:

Number of Tests:
(see Section 7.1 of TAS 124)
(note the locations of all tests on
'Building Information' Detail #2, attached)

n = ___________

Maximum Uplift Pressure:
(as noted on the roof system manufacturer's
Product Approval)

P_{max} = ___________psf

Design Pressures:

Level #1:

Field Area: P_{fl} = ___________psf

Perimeter Area: P_{pl} = ___________psf

Corner Areas: P_{cl} = ___________psf

Extended Corner: P_{ecl} = ___________psf

Design Pressures:

Level #2:

Field Area: P_{f2} = ___________psf

Perimeter Area: P_{p2} = ___________psf

Corner Areas: P_{cl2} = ___________psf

Extended Corner: P_{ec2} = ___________psf

Design Pressures:

Level #3:

Field Area: P_{ff3} = ___________psf

Perimeter Area: P_{p3} = ___________psf

Corner Areas: P_{c3} = ___________psf

Extended Corner: P_{ec3} =___________psf

Note: If the number of levels on the building/project exceeds three (3), record design pressures for additional levels in a similar format.

DATA RECORDING SHEET: **Level #** ________

Bell Chamber Test **Test #** ________

Check the appropriate box for field, perimeter, corner or extended corner.

	Field Area	**Perimeter Area**
	Corner Area	**Extended Corner Area**
Uplift Pressure (psf)	Starting Deflection (inch)	Ending Deflection (inch)
15 psf	0.00"	________"
30 psf	_______"	________"
________psf	_______"	________"
________psf	_______"	________"
________psf	_______"	________"
________psf	_______"	________"
________psf	_______"	________"
________psf	_______"	________"
________psf	_______"	________"

Check either 'pass' or 'fail:' pass fail

If the test resulted in failure, complete the following:
Suspected mode of failure: ____

____

____

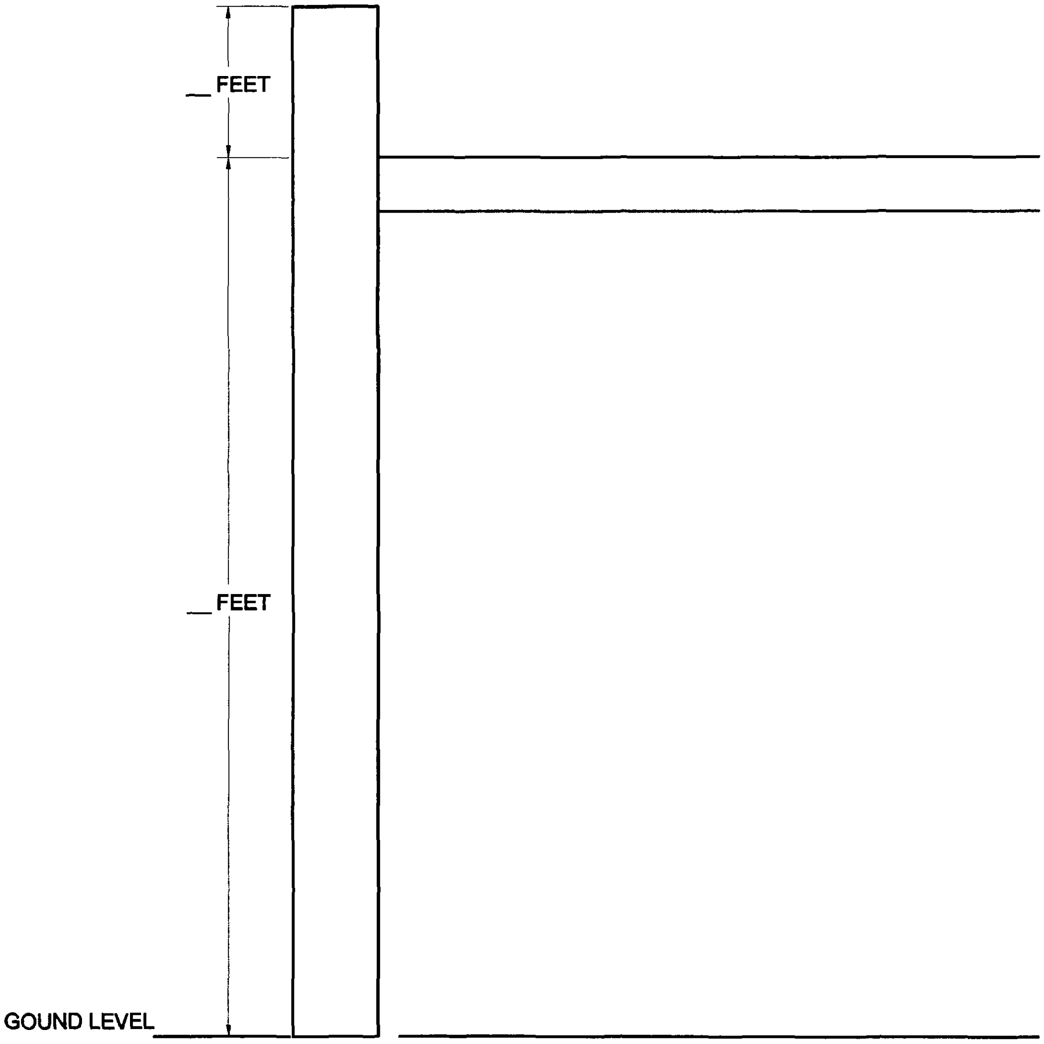
Was a test cut taken to confirm the mode of failure? yes no

____

____

Notes: **Provide one of these 'Data Recording Sheets' for each Bell Chamber Test conducted on each roof level. Multiple deck types shall be treated as separate roof levels. Stair towers, mechanical penthouses and mechanical rooms shall have a minimum of one (1) test conducted.**

INSERT BUILDING AND PARAPET HEIGHTS.
(IF NO PARAPET EXISTS, INSERT "N/A")

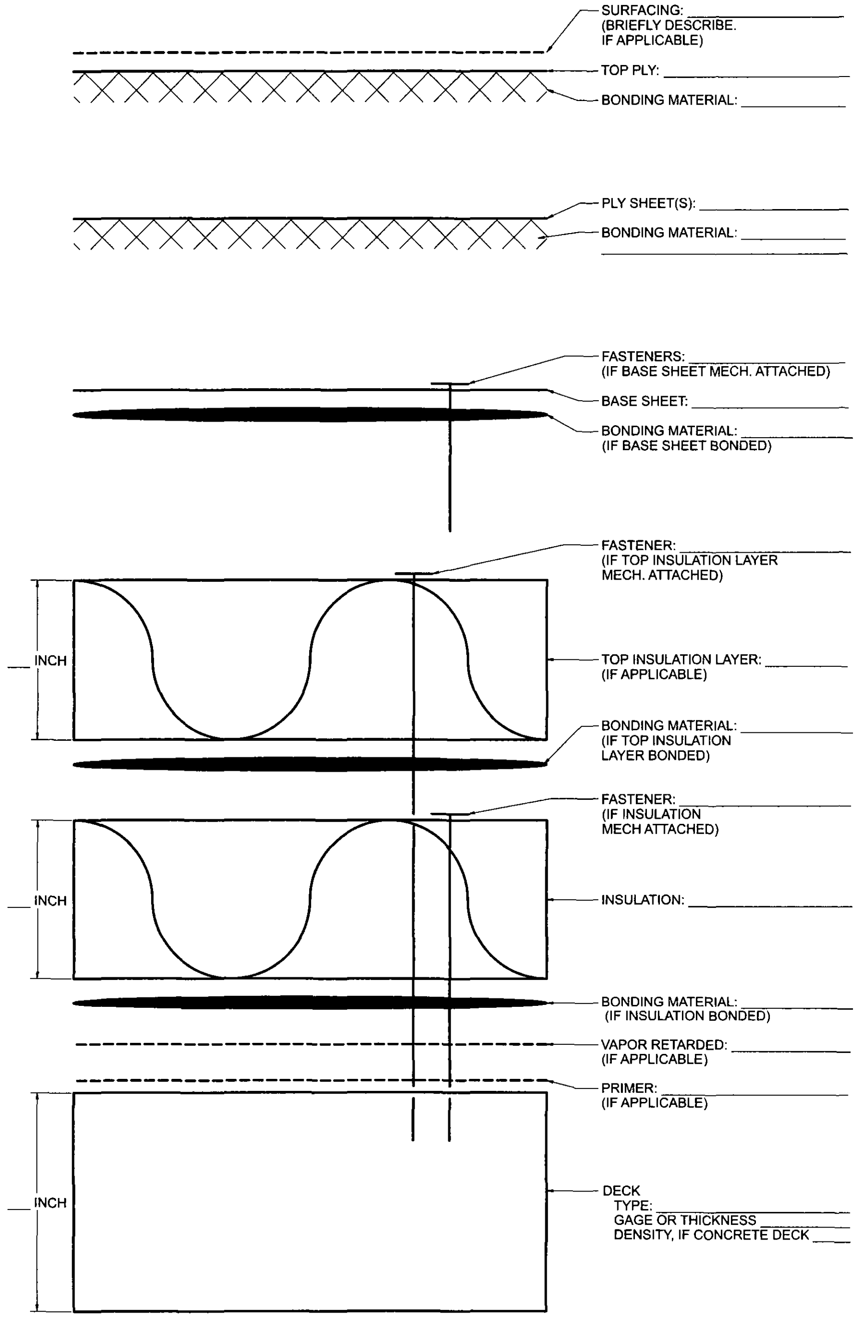


ROOF SYSTEM INFORMATION - DETAIL #1

SKETCH ROOF PLAN INDICATING ALL 'LEVEL #'S' AND THE LOCATION OF ALL TESTS CONDUCTED ON EACH LEVEL (i.e. 'T1', 'T2',.....'Tn'). INCLUDE THE DIMENSIONS OF EACH LEVEL AND ANY ROOF DRAINS, SLOPES, AND/OR ROOF TOP EQUIPMENT WHICH EXISTS ON THE ROOF.

BUILDING INFORMATION - DETAIL #2

FILL IN EXISTING ROOFING COMPONENTS WHICH MAKE UP ROOF SYSTEM ASSEMBLY AND THICKNESS OF DECK AND INSULATION LAYER(S) (WHERE ROOFING COMPONENT NOT USED IN ROOF SYSTEM ASSEMBLY. FILL IN WITH "N/A")



ROOF SYSTEM INFORMATION - DETAIL #3

TESTING APPLICATION STANDARD (TAS) 125-03

STANDARD REQUIREMENTS FOR METAL ROOFING SYSTEMS

1. Scope:

1.1 This Protocol covers the testing requirements for structural and non-structural (architectural) metal roofing systems and the approval process for all systems, which have successfully met the testing criteria.

1.2 All testing shall be conducted by a certified testing agency and all test reports, including calculations, shall be signed and sealed by a Professional Engineer.

2. Referenced Documents:

2.1 *The Florida Building Code, Building.*

2.2 *Underwriters Laboratories, Inc.*

UL 580	Tests for Uplift Resistance of Roof Assemblies
UL 1897	Standard for Roof Covering Systems Annual Roofing Materials and Systems Directory

2.3 *Application Standards*

TAS 201	Impact Test Procedures
TAS 100	Test Procedure for Wind Driven Rain Resistance of Discontinuous Roof Systems
TAS 100A	Test Procedure for Wind and Wind Driven Rain Resistance and for Increased Wind Speed Resistance of Soffit Ventilation Strip and Continuous or Intermittent Ventilation System Installed at the Ridge Area
TAS 110	Testing Requirements for Physical Properties of Roof Membranes, Insulation, Coatings and Other Roofing Components
RAS 111	Standard Requirements for Attachment of Perimeter Wood Blocking and Metal Flashings
RAS 113	Standard Requirements for Job Site Mixing of Roof Tile Mortar

2.4 *ASTM Standards*

D 1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
E 1592	Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference.
E 380	Excerpts from Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.5 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions - For definitions of terms used in this Protocol, refer to ASTM D 1079; and/or the RCI Glossary of Terms; and/or Chapter 2 and Section 1513 of the *Florida Building Code, Building* and/or T125-5.1 and T125-5.2 herein. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units—For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 The requirements outlined herein provide:

1. A means of establishing the criteria for water infiltration resistance; impact loading; and/or, uplift loading

of metal roofing systems for use within the High-Velocity Hurricane Zone jurisdiction; and,

2. A guideline for metal roofing system manufacturers in order to obtain a roof system assembly Product Approval.

5. Applicable Metal Roofing System Constructions

5.1 Structural Metal Roofing Systems

5.1.1 Structural Metal Roofing System - Any metal roof system, which is designed to act as a water shedding and waterproofing layer and is capable of spanning support joists or purlins without additional reinforcement or structural layers. No underlayment is included in a structural metal roofing system.

- Structural metal roof panels shall be not less than 24 gage.
- Deflection of structural metal roof panels shall not exceed L/240.
- Minimum roof decking uplift loads shall comply with ASTM E1592, as noted herein.
- The resistance to uplift pressure of structural metal roof panels, as determined in compliance with ASTM E 1592, shall be subject to a margin of safety of 2.
- Metal roof decking shall be designed without an allowable increase in stresses of $^1/_3$ due to wind load.
- Structural metal roofing systems shall be tested in compliance with the requirements set forth in T125-7 of this Protocol as well as the physical property requirements set forth in TAS 110.

5.2 Non-Structural (Architectural) Metal Roofing Systems

5.2.1 Non-Structural (Architectural) Metal Roofing System - Any metal roof system which requires the support of an independent structural roof deck. A non-structural metal roofing system shall have a water shedding layer mechanically attached to the structural roof deck.

- Testing for uplift resistance for Non-Structural (Architectural) Metal Roof Assemblies shall be performed in accordance with UL 580 as modified herein, and shall be subject to a margin of safety of 2.
- The independent structural roof deck over which a non-structural metal roofing system is to be installed shall be in compliance with Chapter 22 (*High-Velocity Hurricane Zones*), for metal, or Chapter 23 (*High-Velocity Hurricane Zones*), for wood, of the *Florida Building Code, Building*.
- Wood decking, over which a non-structural metal roofing system is to be installed, shall be not less than $^{15}/_{32}$ in. thick. Minimum fastening for decking shall be in accordance with the *Florida Building Code (High-Velocity Hurricane Zone)*.
- Non-structural metal roofing systems shall be tested in compliance with the requirements set forth in T125- 7 of this Protocol as well as the physical property requirements set forth in TAS 110.

6. Precautions:

6.1 This Protocol may involve hazardous materials, operations, and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Testing Requirements:

7.1 General—All structural and non-structural metal roofing systems shall be subjected to the following testing unless otherwise noted.

7.2 Physical Property Testing

7.2.1 All structural and non-structural metal roofing systems shall be tested for the physical properties set forth in T125-20 of TAS 110.

7.3 Wind Driven Rain Testing

7.3.1 All structural and non-structural metal roofing systems shall be tested for resistance to wind driven rain in compliance with TAS 100 for slopes 2:12 and greater or TAS 114 Appendix G (FM 4471) for slope less than 2:12.

7.3.1.1 For systems with a valley assembly, testing in accordance with TAS 100 shall be required in addition to testing in accordance with TAS 114, Appendix G.

7.3.1.2 For system approvals including horizontal joints, a minimum of two horizontal joints shall be incorporated in the TAS 100 test and one horizontal joint in TAS 114 test of the test specimens.

7.3.2 All ridge ventilation systems shall be tested for resistance to wind driven rain in compliance with TAS 100(A).

7.4 Impact Testing

7.4.1 Structural Metal Roofing Systems

- All structural metal roofing systems having a thickness less than 22 gage shall be tested for impact resistance in compliance with TAS 201, as amended below. Structural metal roofing systems having a thickness greater than or equal to 22 gage shall be exempt from impact testing.

7.4.2 Non-Structural Metal Roofing Systems

- All non-structural metal roofing systems which are less than 26 gage in thickness shall be tested for impact resistance in compliance with TAS 201, as amended below.

7.4.3 TAS 201 Amendments for Metal Roofing Systems

- Panel thickness, finish, fasteners, sealing washers, and overall design shall be in compliance with Section 2222.4 (for structural) or Section 2222.5 (for non-structural) of the *Florida Building Code, Building*.
- The metal roofing system test specimen shall be constructed in compliance with the manufacturer's published installation instructions and the minimum requirements set forth in Section 2222.4 (for structural) or Section 2222.5 (for non-structural) of the *Florida Building Code, Building*. The requirements from the *Florida Building Code, Building* shall take precedence.
- Testing in compliance with TAS 203, as noted in T201-12.1 of TAS 201, is not required for either structural or non-structural metal roofing systems.

7.5 Air Pressure/Resistance Testing for Structural Metal Roofing Systems

7.5.1 All structural metal roofing systems shall be tested in compliance with ASTM E 1592, as modified in T125-9 of this Protocol. Not less than three (3) ASTM E 1592 tests shall be conducted for each metal roofing system.

7.5.2 The average maximum positive and negative pressures attained during the three (3) ASTM E 1592 tests of a particular structural metal roofing system shall be included in the manufacturer's Roof Assembly Product Approval for reference after a 2 to 1 margin of safety is applied.

7.6 Uplift Resistance Testing for Non-Structural Metal Roofing Systems

7.6.1 All nonstructural metal roofing systems shall be tested in compliance with UL 580, as modified in T125-8 of this Protocol. Not less than three (3) specimens shall be conducted for each metal roofing assembly.

7.6.2 A margin of safety of 2 to 1 shall be applied to all uplift resistance test results.

7.6.3 The maximum allowable design pressure for the two tested specimens representing a typical roof field installation as specified in T125-7.6.3 shall be established by applying a 2 to 1 margin of safety to the average tested pressure of the specimens. The established maximum allowable design pressure shall be listed in the Roof Assembly Product Approval.

The maximum allowable design pressure for the third specimen representing a typical roof corner condition as specified in T125-7.6.3 shall be established by applying a 2 to 1 margin of safety to the tested pressure of the specimen. The established maximum allowable design pressure shall be listed in the Roof Assembly Product Approval.

Extrapolation of either the field and/or corner maximum allowable design pressures listed in the Roof Assembly Product Approval shall not be permitted.

8. UL 580 (as modified for the *Florida Building Code, Building*):

8.1 Scope

8.1.1 The test method specified in this standard is intended to determine the average uplift resistance of roof assemblies consisting of the roof deck and roof covering materials. It is applicable to any type of roof assembly which is adaptable to the test equipment. Tests to evaluate other potential hazards of roof assemblies are not within the scope of these requirements.

8.1.2 The purpose of this test is to evaluate the comparative resistance of roof assemblies to positive and negative pressures. Not less than three (3) test specimens shall be constructed and tested. Two test specimens shall simulate roof field installation conditions, and one test specimen shall simulate roof corner conditions.

8.1.3 The test evaluates the roof deck, its attachment to supports, and roof covering materials, if used. It does not evaluate roofs adjacent to chimneys, overhanging eaves, or the like, connections of the assembly to main structural supports (girders, columns, or the like), structural integrity of secondary supports (purlins, joists, bulb tees, or the like), or deterioration of roofing materials.

8.2 General

8.2.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

8.2.2 Any undated reference to a code of standard shall be interpreted as referring to the latest edition of that code or standard.

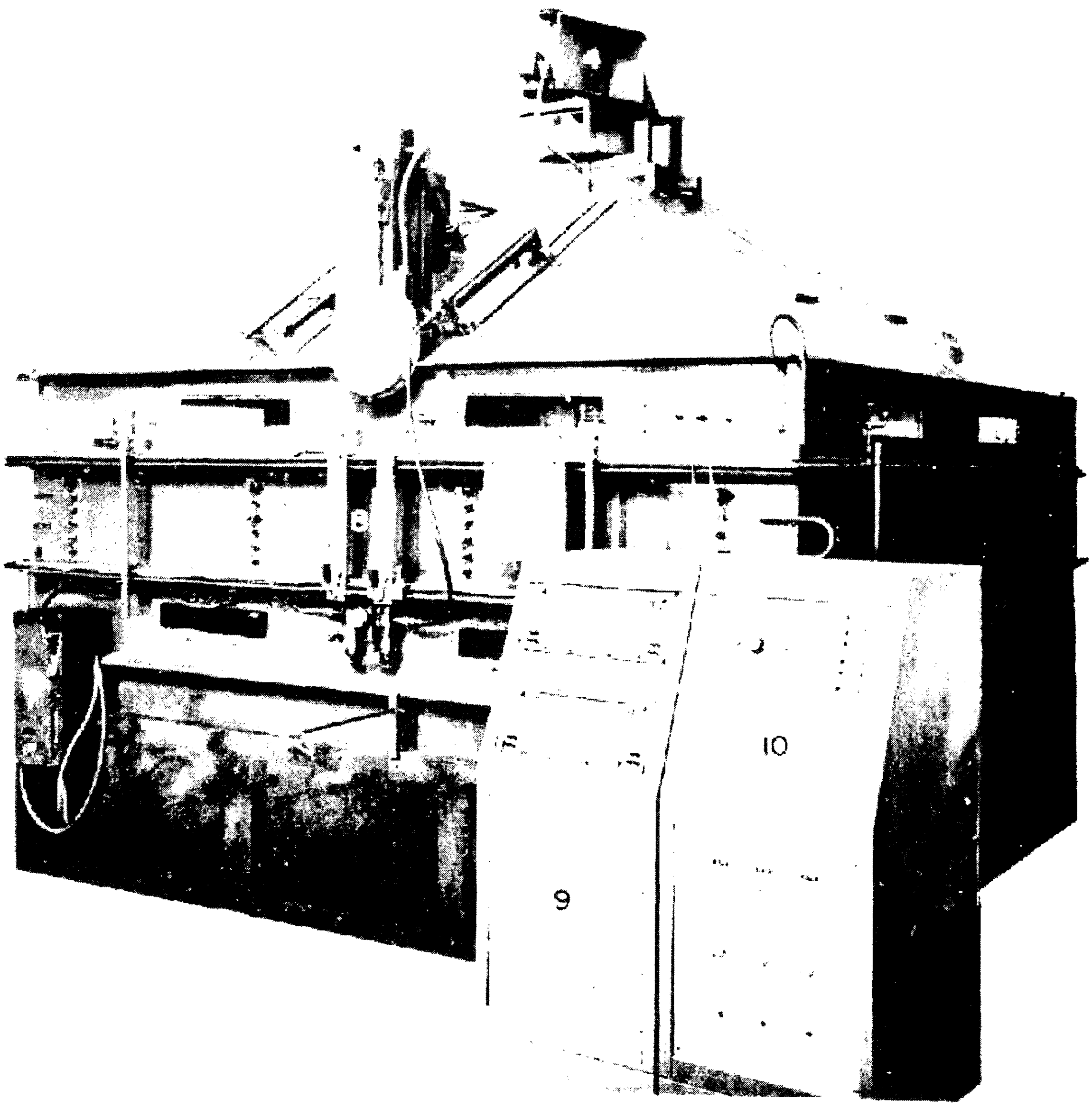


FIGURE 8-1
ASSEMBLED UPLIFT TEST APPARATUS FOR UL 580

1. Pressure Chamber
2. Vacuum Chamber
3. Test Frame
4. Vacuum Blower
5. Slide Damper-Automatic
6. Slide Damper-Manual
7. Starters for Vacuum and Pressure Blowers
8. Pressure Manometers
9. Pressure Recording Equipment
10. Automatic Vacuum Controls

8.3 Test Apparatus

8.3.1 The test apparatus is to consist of three sections: a top section to create a uniform vacuum, a center section in which the roof assembly is constructed, and a bottom section to create a uniform positive pressure. See Figure T125-8-1. Each section is to be sealed to maintain the specified pressures.

8.3.2 The inside dimensions of the test apparatus is to be a minimum of 10 by 10 feet (3.05 by 3.05 m).

8.3.3 The test chamber is to be capable of applying steady positive pressures on the underside of the test assembly and both steady and oscillating negative pressures, as specified, upon the top surface.

8.3.4 Recording equipment is to be provided to make a permanent record of the pressure levels developed in the test as a function of time.

8.3.5 T125-8.4 - T125-8.6 contain a specification of the presently used test apparatus. Design modifications may be made provided that the test results are equivalent to the results obtained from the specified apparatus.

8.4 Pressure Chamber

8.4.1 The pressure chamber is to be formed from C12 x 30 channels and is to measure 10 by 10 feet (3.05 by 3.05 m) by 9 inches (229 mm) deep. A $4^{1}/_{2}$ inch (114 mm) wide by $^{1}/_{4}$ inch (6.4 mm) thick steel plate is to be welded around the top of the chamber.

8.4.2 The floor of the pressure chamber is to be fabricated from $^{1}/_{8}$ inch (3.2 mm) thick sheet steel, welded at the seams and supported by five 3 by 8.5 inch (76 by 190 mm) steel shapes. The chamber is to be supported by an MC8 x 20 channel at each side and a W8 x 28 beam at each corner.

8.4.3 Several windows constructed of break-resistant glazing material are to be installed in the chamber walls to allow observation of the underside of the test assembly.

8.4.4 Flood lights are to be mounted in the chamber for illumination of the underside of the test assembly.

8.4.5 Air is to be admitted into the chamber through a 6 by 6 inch (152 by 152 mm) opening cut into the bottom of the chamber.

8.4.6 A steel baffle is to be placed over the air inlet opening for even distribution of air pressure. The baffle consists of two vanes with the lower vane measuring 22 by 22 inches (559 by 559 mm) and the upper vane measuring 16 by 16 inches (406 by 406 mm). The vanes are set at an angle of 30° from the horizontal.

8.4.7 Air to be provided by a blower attached to a 3 horsepower (2.2 kW output) electric motor that is capable of delivering 862 cubic feet (24.4 m^3) of air per minute at a static pressure of 24 inches (610 mm) of water.

8.4.8 The pressure blower starter controls are to be located on the side of the chamber for ease of access and rapid shut down.

8.4.9 The inlet pressure is to be controlled at the blower by a manually operated steel damper measuring 2 by 8 inches (51 by 457 mm) which is mounted in a sheet steel collar. The chamber pressure is to be controlled by an automatic relief damper measuring $4^{3}/_{4}$ by $11^{3}/_{4}$ inches (121 by 298 mm) located on the bottom of the chamber. The automatic damper is to be controlled by means of an adjustable weight system.

8.4.10 The air pressure is to be measured at five points by means of $^{1}/_{4}$ inch (6.4 mm) outside diameter copper tubing extending from the floor into the chamber at an angle of 45°

from the floor. Each of four tubes is to be diagonally located 42 inches (1067 mm) from a corner of the chamber. A fifth tube is to be located 18 inches (457 mm) from the center of the air inlet opening. The end of each tube is to be 7 inches (178 mm) above the chamber floor. The tubes are to be connected through $^1/_4$ inch valves into a manifold that, in turn, is to be connected to a manometer having a range of 0 - 25 inches of water (0 - 6221 Pa), graduated into 0.10 inch (24.9 Pa) increments.

8.5 Vacuum Chamber

8.5.1 The vacuum chamber is to be formed from C12 x 30 channels and is to measure 10 by 10 feet (3.05 by 3.05 m) by 12 inches (305 mm) high at the base. A $4^1/_2$ inch (114 mm) wide by $^1/_4$ inch (6.4 mm) thick steel plate is to be welded to the bottom of the channels. A reinforced hood, constructed from 0.105 inch (2.66 mm) thick steel with $2^1/_2$ by $2^1/_2$ by $^1/_2$ inch (64 by 64 by 12.7 mm) angles at the corners and $2^1/_2$ by $2\,^3/_4$ inch (64 by 70 mm) T125-s at the center, is to be mounted on the base.

8.5.2 Several windows constructed of break-resistant glazing material are to be installed in the test chamber base to allow observation of the upper face of the test assembly.

8.5.3 The hood is to have a 30° slope from the horizontal at each side and is to have observation windows constructed of break-resistant glazing material in each wall.

8.5.4 The hood is to be terminated in a 24 by 24 inch (610 by 610 mm) metal platform constructed from $^1/_8$ inch (3.2 mm) thick steel plate. A 7 inch (178 mm) diameter opening is to be cut into the plate for the blower.

8.5.5 Negative pressure is to be provided by a blower and 3 horsepower (2.2 kW output) motor, which are to be mounted on top of the chamber with their shafts in a vertical position. The combination is to be capable of delivering 862 cubic feet (24.4 m^3) of air per minute at a static pressure of 11 inches (300 mm) of water.

8.5.6 The vacuum blower starter controls are to be located on a platform welded to the top of the hood.

8.5.7 The pressure in the vacuum chamber is to be controlled by an automatic damper measuring 18 by $2^1/_4$ inches (457 by 57 mm). The damper door is to be moved by means of an air motor hooked to an air line and controlled by pressure switches located in a control console.

8.5.8 An additional manually controlled sliding damper is to be located on the sloped wall of the chamber. It is to be constructed of $^1/_8$ inch (3.2 mm) thick steel plate and a screw gear which opens or closes the damper by turning. The damper is to measure 6 by 18 inches (152 by 457 mm).

8.5.9 Sheet metal baffles are to be located on the underside of the damper to prevent direct air flow onto the test assembly.

8.5.10 The air pressure to be measured at five points by means of $^1/_4$ inch (6.4 mm) outside diameter copper tubing extending from the floor into the chamber at an angle of 45° to the floor. Each of four tubes is to be diagonally located 18 inches (457 mm) from a corner of the chamber. The ends of these four tubes are to be 8 inches (203 mm) above the chamber floor. The fifth tube is to enter the chamber at a point 12 inches (305 mm) from the center of the exhaust opening, and its end is to be 6 inches (152 mm) below the opening. The tubes all are to be connected through $^1/_4$ inch valves into a manifold that, in turn, is to be connected to a manometer having a range of 0 -12 inches of water (0 - 2988 Pa) graduated into 0.10 inch (24.9 Pa) increments.

8.5.11 An additional $^1/_4$ inch (6.4 mm) outside diameter copper tube is to be connected from the manifold to an exterior junction for use of the pressure switches which control the automatic damper.

8.5.12 Flood lights are to be mounted in the chamber for illumination of the top surface of the test assembly.

8.5.13 Lifting hooks fabricated from $^5/_8$ inch (15 mm) diameter steel rod are to be welded at each corner of the hood.

8.6 Test Frame

8.6.1 The test frame is to be fabricated from C15 x 33.9 steel channels and measures 10 by 10 feet (3.05 by 3.05 m) by 15 inches (381 mm) deep. A $4^1/_2$ inch (114 mm) wide by $^1/_4$ inch (6.4 mm) thick steel plate is to be welded to the top and bottom of the channels at all four sides.

8.6.2 Machine nuts used for attaching assembly supports to the test frame are to be welded to all four sides of the test frame. The nuts are to be located 36 inches (914 mm) on center, beginning 18 inches (457 mm) from the frame center lines. Each line includes six $^5/_8$ inch (15 mm) diameter nuts spaced 2 inches (51 mm) apart.

8.6.3 A rubber gasket is to be cemented to the top flange of the test frame.

8.6.4 Lifting hooks fabricated from $^5/_8$ inch (15 mm) diameter steel rods are to be welded to each corner of the test frame.

8.7 Test Procedure

8.7.1 The test assembly shall be subjected to positive and negative pressures at the values and time

TABLE T125-1
TEST PRESSURES

TEST PHASE	TIME DURATION (MINUTES)	NEGATIVE PRESSURE		POSITIVE PRESSURE	
		psf (kPa)	INCHES (mm) OF WATER	psf (kPa)	INCHES (mm) OF WATER
Class 30 (not an obtainable rating)					
1	5	16.2 (0.79)	3.1 (79)	0.0 (0.00)	0.0 (0)
2	5	16.2 (0.79)	3.1 (79)	13.8 (0.66)	2.7 (69)
3	60	8.1- 27.7 (0.39-1.33)	1.5-5.3 (38-135)	13.8 (0.66)	2.7 (69)
4	5	24.2 (1.16)	4.7 (119)	0.0 (0.00)	0.0 (0)
5	5	24.2 (1.16)	4.7 (119)	20.8 (1.00)	4.0 (102)
Class 60 (not an obtainable rating)					
1	5	32.3 (1.55)	6.2 (157)	0.0 (0.00)	0.0 (0)
2	5	32.3 (1.55)	6.2 (157)	27.7 (1.33)	5.3 (135)
3	60	16.2- 55.4[a] (0.79-2.66)	3.1-10.7 (79-272)	27.7 (1.33)	5.3 (135)
4	5	40.4 (1.94)	7.8 (198)	0.0 (0.00)	0.0 (0)
5	5	40.4 (1.94)	7.8 (198)	34.6 (1.66)	6.7 (170)
Class 90 (maximum combined uplift pressure of 105 psf)					
1	5	48.5 (2.33)	9.3 (236)	0.0 (0.00)	0.0 (0)
2	5	48.5 (2.33)	9.3 (236)	41.5 (1.99)	8.0 (203)
3	60	24.2- 48.5[a] (1.16-2.33)	4.7-9.3 (119-236)	41.5 (1.99)	8.0 (203)
4	5	56.5 (2.71)	10.9 (277)	0.0 (0.00)	0.0 (0)
5	5	56.5 (2.71)	10.9 (277)	48.5 (2.33)	9.3 (236)

[a] Oscillation frequency as specified in T125-8.7.1.

duration specified in Table T125-1. Negative pressure is to be applied to the top surface of the assembly and positive pressure is to be applied to the bottom surface. During Phase 3 of the test, the oscillation frequency is to be 10 +/-2 seconds per cycle.

8.7.2 For a Class 90 (105 psf) rating the test pressure shall not exceed the specified values by more than 0.31 inches of water (77.2 Pa) for any test phase, the average pressure is not to vary by more than 0.25 inch of water (62.2 Pa) from the specified values.

8.7.3 Upon completion of each 60-minute oscillation phase and at the conclusion of each class level, the assembly is to be examined and observations recorded.

8.7.4 Subsequent to the completion of Phase 5 of the Class 90 test sequence, the test specimen may be subjected to additional static uplift pressures. Continuation of the test to increased pressure levels is the option of the manufacturer.

8.7.4.1 The positive pressure supplied from below shall be maintained at 48.5 psf (9.3 kPa).

8.7.4.2 The negative uplift pressure shall be supplied from above. The initial negative static uplift pressure shall be 63.5 psf. Subsequent pressure intervals shall increase in increments of 15 psf, with each pressure level held for one minute, until failure or until the desired uplift pressure is attained.

8.7.5 Vertical movement of the assembly during the tests is to be recorded.

8.7.6 Repairs or modifications, except to stop air leakage along the periphery, are not to be made to the assembly during the test.

8.8 Test Assembly Construction Features

8.8.1 The test assembly is to be representative of the construction for which classification is desired as to materials, workmanship, and details such as dimensions of parts, and shall be built under conditions representative of those in building construction. Properties of the materials and ingredients used in the test assembly together with their location and method of attachment are to be determined and recorded.

8.8.2 For non-structural metal roofing assemblies installed over wood decks, plywood shall be APA 42/20 span rated sheathing of a minimum thickness of $^{15}/_{32}$ in. Ends shall be butted, not blocked. All butt and side joints shall be left un-sealed, positive pressure shall freely flow through the deck. Minimum deck attachment shall be in compliance with the *Florida Building Code, Building*.

8.8.3 The dimensions of the test assembly are to be a minimum of 10 by 10 feet (3.05 by 3.05 m). The test assembly shall contain side and end joints if such occur in field installation. The test assembly shall consist of secondary bearing members, such as purlins and joists, to which the roof decking is fastened or on which insulation and roof coverings are applied.

8.8.4 The assembly components, including secondary members, are to be located to best represent field installations within the restraints provided by the test frame.

8.8.5 The periphery of the test assembly is to be sealed to prevent passage of air under pressure.

8.8.6 The test assembly is to be cured at room temperature for a period until representative field strength, humidity, and temperature are achieved.

8.8.7 Not less than three test specimens as described above shall be constructed and tested.

8.8.8 Proper Use of Film and Air Bags

8.8.8.1 Where plastic film is used to seal joints to allow pressurization of the interior or underside surface of the roof specimen it shall contact all surfaces of the panel and shall not interfere with the air passage to the specimen or the movement of adjacent parts. Film shall not bridge or otherwise block the gap at the base of a standing seam, as in Figure T125-9-3. Such bridging or blocking prevents lateral movement and proper pressurization of the specimen and yields non-conservative results whether it be a flat film sealed at the edges or an air bag.

- Longitudinal pleats that fit up into the rib on both sides of a clip, as in Figure T125-9-4 herein, ensure full contact and eliminate restraint.
- Multiple longitudinal air bags wider than the panel module, as in Figure T125-9-5 herein, provide the same effect without the need to perforate the air bag with the anchor fastener. Where either of these interferes with proper clip engagement, all seals must be limited to the perimeter of the test specimen.
- Multiple crosswise air bags, as in Figure T125-9-6 herein, do not make full contact and will hamper panel distortion. Plastic film must always lie between the panel and the crosswise support structure to provide continuous longitudinal contact. Other methods of sealing that demonstrate equivalent distortion as air pressure are acceptable.

8.9 Classifications

8.9.1 A Class 90 uplift classification shall be obtainable, having a maximum combined positive and negative pressure of 105 psf.

8.9.2 To obtain a Class 90 rating, the sample shall be subjected to the Class 30 and Class 60 tests, in that order, prior to the Class 90 test.

8.9.3 To obtain an increased maximum uplift resistance, the sample shall be subjected to the Class 30, Class 60 and Class 90 tests, in that order, prior to the static test.

8.9.4 The test assembly shall retain its structural integrity during or following the test without evidence of permanent damage. The following are examples of permanent damage.

- Buckling of rolled members that results in permanent loss of stiffness as determined by separate load tests comparing buckled and unbuckled members.
- Separation of components or permanent distortion that interferes with the function of the system or inability to carry additional load.
- Sidejoint disengagement.
- Failure of one or more fasteners of any type.
- Any permanent deformation of nonstructural roof systems exceeding 1.00 inch in diameter.

8.10 Interpretation of Results

8.10.1 The maximum allowable design pressure for the two tested specimens representing a typical roof field installation as specified in T125-7.6.3 shall be established by applying a 2 to 1 margin of safety to the average tested pressure of the specimens. The established maximum allowable design pressure shall be listed in the Roof Assembly Product Approval.

The maximum allowable design pressure for the third specimen representing a typical roof corner condition as specified in T125-7.6.3 shall be established by applying a 2 to 1 margin of safety to the tested pressure of the specimen. The established maximum allowable design pressure shall be listed in the Roof Assembly Product Approval.

Extrapolation of either the field and/or corner maximum allowable design pressures listed in the Roof Assembly Product Approval shall not be permitted.

9. ASTM E 1592:

9.1 Scope

9.1.1 This test method covers the evaluation of the structural performance of sheet metal panels and anchor-to-panel attachments for roof or siding systems under uniform static air pressure differences using a test chamber or support surface.

9.1.2 This test method is applicable to standing seam, trapezoidal, ribbed, or corrugated metal panels in the range of thickness from 0.012 in. to 0.050 in. (0.3 to 1.3 mm) and applies to the evaluation of single-skin construction or one layer of multiple-skin construction. It does not cover requirements for the evaluation of composite or multiple-layer construction.

9.1.3 Proper use of this test method requires knowledge of the principles of pressure and deflection measurement.

9.1.4 This test method describes optional apparatus and procedures for use in evaluating the structural performance of a given system for a range of support spacings or for confirming the structural performance of a specific installation.

9.1.5 The values stated in inch-pound units are to be regarded as the standard. The metric equivalents of inch-pound units are approximate.

9.1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific precautionary statements, see T125-9.7.

9.1.7 The text of this standard references notes exclusive of those from tables and figures. These notes and footnotes provide explanatory material and shall not be considered as requirements of the standard.

9.1.8 Not less than three (3) identical test specimens shall be constructed and tested.

9.2 Reference Documents

9.2.1 ASTM Standards:

A) 370 Test Methods and Definitions for Mechanical Testing of Steel Products.

B) 557 Method of Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products

9.2.2 Aluminum Association Standard: Aluminum Formed-Sheet Building Sheathing Design Guide, Appendix B of specifications for Aluminum Structures, 1986 Edition

9.2.3 AISI Standards:

Load and Resistance Factor Specification for Cold-Formed Steel Structural Members, 1991 Edition Specification for the Design of Cold- Formed Steel Structural Members, 1996 Edition with the 1999 Addendum, Part I of the Cold Form Steel Design Manual

9.2.4 American Society of Civil Engineers: ASCE 7 Minimum Design Loads for Buildings and Other Structures. (Formerly ANSI A58.1)

9.3 Terminology - Descriptions of Terms Specific to This Standard.

9.3.1 Anchor, n - a fastener, bolt, screw, or formed device such as a clip that connects panels to the support structure.

9.3.2 Anchor Failure, n - any failure at the anchor device, including separation of the device from the panel, of the device itself, or of the connection to the structural support.

9.3.3 Crosswise Restraint, n - any attachment in the flat of a panel between structural elements that controls or limits pan distortion under pressure.

9.3.4 Failure, n - separation of components or permanent distortion that interferes with the function of the system or inability to carry additional load.

9.3.5 Interior Support, n - any support other than those at either extreme in a series of supports for a continuous panel.

9.3.6 Pan Distortion, n - displacement under load of normally flat portions of a panel profile as measured normal to the plane of the roof or wall surface.

9.3.7 Panel Deflection, n - displacement under load measured normal to the plane of the roof or wall surface of a longitudinal structural element as measured from a straight line between structural supports.

9.3.8 Permanent Deformation, n - the permanent displacement in any direction from an original position that remains after an applied load has been removed.

9.3.9 Reference Zero Load, n - nominal pressure applied to a specimen to provide a reference position free of variations from internal stresses or friction within the system assembly.

9.3.10 Rib Spread, n - panel distortion under load at the base of a rib or standing seam as measured crosswise to the rib in the plane of the roof or wall surface.

9.3.11 Span Length, n - the center-to-center distance between anchors or supports measured parallel to the longitudinal axis of the panel.

9.3.12 Specimen, n - the entire assembled unit submitted for testing, as described in T125-9.8.

9.3.13 Specimen Length, n - the distance from center to center of the end supports; the sum of individual span lengths.

9.3.14 Structural Element, n - the width of a panel profile as measured between center lines of repeating longitudinal stiffeners for continuously supported panels in a positive load test or the width between anchor attachments to repeating stiffener elements in a negative load test.

9.3.15 Test Load, n - the difference in static air pressure (positive or negative) between the inside and outside face of the specimen, expressed in pounds-force per square foot (lbf/ft^2) or pascals (Pa).

9.3.16 Test Panel Length, n - specimen length plus overhangs.

9.3.17 Ultimate Load, n - the difference in static air pressure (positive or negative) at which failure of the specimen occurs, expressed in pounds-force per square foot (lbf/ft^2) or pascals (Pa).

9.3.18 Unlatching Failure, n - disengagement of a panel seams or anchors that occurs in an unloaded assembly due to permanent set or distortion that occurred under a previous load condition.

9.3.19 Yield Load, n - that pressure at which deflection increases are no longer proportional to the increasing pressure. Yielding is not failure.

9.3.20 Zero Load, n - the absence of air pressure difference across the specimen.

9.4 Summary of Test Method

9.4.1 This test method consists of the following: (1) sealing the test specimen into or against one face of a test chamber; (2) supplying air to, or exhausting air from, the chamber at the rate required to maintain the test pressure difference across the specimen; and, (3) observing, measuring, and recording the deflection, deformations, and nature of any failures of principal or critical elements of the panel profile or members of the anchor system.

9.4.2 The increments of load application shall be chosen such that a sufficient number of readings will be obtained to determine the load deformation curve of the system.

9.4.3 End and edge restraint shall be representative of field conditions, and the unit shall contain sufficient individual components to minimize the effect of variations in material and workmanship.

9.5 Significance and Use

9.5.1 This test method provides a standard procedure to evaluate or confirm structural performance under uniform static air pressure difference. This procedure is intended to represent the effects of uniform loads on exterior building surface elements.

9.5.2 It is also permissible to develop data for load-span tables by interpolating between the test results at different spans

NOTE 1: When applying the results of tests to determine allowable design loads by application of a factor of safety, bear in mind that the performance of a wall or a roof and its components, or both, can be a function of fabrication, installation, and adjustment. The specimen must represent the actual structure closely. In service, the performance can also depend on the rigidity of supporting construction and on the resistance of components to deterioration by various causes, to vibration, to thermal expansion and contraction, etc.

9.6 Apparatus

9.6.1 The description of apparatus is general in nature; any equipment capable of performing the test procedure within the allowable tolerances is permitted. Major components are shown in Figure T125-9-1, herein.

9.6.2 Test Chamber - a test chamber, air bag, or box with an opening, a removable mounting panel, or one open surface in which or against which the specimen is installed. Provide at least two static pressure taps located at diagonally opposite corners to measure the chamber pressure such that the reading is unaffected by the velocity of the air supply to or from the chamber or any other air movement. The air supply opening into the chamber shall be arranged so that the air does not impinge directly on the test specimen with any significant velocity. A means of access into the chamber to facilitate adjustments and observations after the specimen has been installed is optional.

NOTE 2: The test chamber or the specimen mounting frame, or both, must not deflect under the test load in such a manner that the performance of the specimen will be affected. In general, select anchor support members sufficiently rigid that deflection under the test load will be negligible.

9.6.3 Air System-a compressed air supply, exhaust system, or controllable blower is to be provided to develop the required air pressure difference across the specimen. The system shall maintain an essentially constant air pressure difference for the required test period.

NOTE 3: It is convenient to use a reversible blower or separate pressure and exhaust systems to provide the required air pressure difference so that different test specimens can be tested for the effect of positive pressure or the effect of suction (negative pressure) without reversing the position of the test specimen. The use of the same specimen for both positive and negative testing is outside the scope of this test method. If an adequate air supply is available, a completely airtight seal need not be provided around the perimeter of the test specimen and the mounting panel, although it is preferable. However, substantial air leakage will require an air supply of much greater capacity to maintain the required pressure differences.

9.6.4 Pressure-measuring Apparatus - the devices to measure the test pressure difference shall operate within a tolerance of +/-2% of the design pressure, or within 0.1 in. (0.52 psf or 25 pa) of water pressure and be located as described in T125-9.6.1.

9.6.5 Deflection and Distortion Measurement Precision:

9.6.5.1 The means of measuring deflections of structural ribs between the reaction supports and movement of the ribs at the supports shall provide readings within a tolerance of +/-0.01 in. (0.25 mm).

9.6.5.2 The means of measuring pan distortion shall provide readings within a tolerance of +/- $^1/_{16}$ in. (1.5 mm).

9.6.5.3 The means of measuring rib spread shall provide readings within a tolerance of +/-$^1/_{16}$ in. (1.5 mm).

9.6.6 Reading Locations:

9.6.6.1 Support deflection gages or measuring devices so that readings are not influenced by movements of, or within, the specimen or member supports.

9.6.6.2 Minimum, measure the maximum deflection of the panel at the end span and the deflections of the supports of the end span.

9.6.6.3 Measure pan distortion in the middle of at least one panel flat (between structural elements) at a minimum of three locations. Additional reading locations are required to validate freedom from end restraint, as described in T125-9.8.2.2.

9.6.6.4 Rib spread readings are optional for measuring panel distortion for profiles with vertical rib faces. Measure rib spread at the base of the ribs in line with the anchors and at mid span, as required, to meet requirements of T125-9.8.2.2.

9.6.7 Reading Frequency:

9.6.7.1 In all cases except for rib spread, readings shall be taken at initial zero or preload, at each increment of load, and again at the zero or preload to determine permanent set. See T125-9.10.2.4 regarding the selection of zero load.

9.6.7.2 Rib spread readings shall be taken at each increment of load unless stipulated otherwise by the specifying authority.

9.7 Safety Precautions:

9.7.1 Take proper precautions to protect the operating personnel and observers in the event of any failure.

9.8 Test Specimens:

9.8.1 The test specimens shall be of sufficient size to determine the performance of all typical parts of the system. Conditions of structural support shall be simulated as accurately as possible, and the full length and width, including overhangs, shall be loaded. All parts of the test specimen shall be full size, using the same materials, details, and methods of construction and anchorage as used on the actual building. Except for positive load as in T125-9.8.2.2, any partial width sheets shall not be considered in figuring specimen width.

9.8.2 Specimen Width - edge seals shall not contain structural attachments that restrict deflection of the test panel any more than the normal gable condition.

9.8.2.1 For the evaluation of either bending capacity or anchor to panel attachment strength under negative load, the specimen width shall contain not less than three full panels and five structural elements with normal rake or gable supports at both edges. (See Figure T125-9-2, herein.)

9.8.2.2 For the evaluation of panel bending capacity in resisting positive pressure, the specimen width shall be as specified in T125-9.8.2.1 or be not less than 40% of the clear span and include not less than four structural elements with not less than one half the flat distance to the next adjacent nonincluded parallel rib, corrugation, or stiffener on each side.

9.8.3 Specimen Length - for negative (uplift) load tests (or any form of loading that tends to push panels away from the crosswise support), unless the test represents the full length used, the specimen length shall be sufficient to ensure that end seals or attachments do not restrict panel movement at the area under investigation.

9.8.3.1 For the evaluation of anchor to panel strength free of end influence, the arbitrary minimum specimen length, when both ends have crosswise restraint, is 24 ft (7.3 m). Shorter lengths are acceptable when only one end having crosswise restraint is a minimum of 8 ft (2.4 m) from at least one row of interior anchors. When both ends are free of crosswise restraint, the minimum specimen length is 10 ft (3 m) (see Table T125-1). When crosswise restraint is removed from both ends, the normal failure mechanism is the anchor connection to the seam. Other modes of failure or performance must be evaluated using one or both ends restrained.

9.8.3.2 For the evaluation of anchor to panel strength, the results are deemed to be free of end influence that the sample is outside the effect of the end condition as follows:

9.8.3.2.1 When a maximum mid-span panel distortion reading of an identical 24-ft (7.3-m) panel do not exceed (within the tolerance of the measurement) the maximum readings on the shorter setup; or

9.8.3.2.2 When maximum mid-span panel distortion reading does not exceed (within the tolerance of the measurement) the midspan distortion readings at least 4 ft (1.2 m) on both sides of at least one purlin.

9.8.3.3 For positive load tests, where the panels are supported to resist the applied load at each structural element in the midroof area as well as at the ends, the specimen length is not restricted.

9.8.4 Structural supports used in the test shall be of sufficient strength and rigidity to minimize deflection of the assembly. For supports used in positive pressure tests, due consideration must be given to the support.

9.8.5 End conditions that simulate eave or ridge flashing situations in which the panel terminates at or slightly beyond the purlin are considered to have crosswise restraint and influence distortion for some distance along the length of the panel. An open-end condition is one without crosswise restraint.

9.8.5.1 It is permissible to reinforce open-end conditions to prevent non-typical failures of clip to panel attachment or of web buckling caused by proximity of the free edge to the support. Acceptable reinforcement includes longitudinal stiffeners in the flats to prevent buckling of flats. Also acceptable are seam fasteners at the ends of ribs to prevent un-seaming from the free end. The reinforcement shall not restrict crosswise panel deformation nor cause the end seal to pull away from the pan as panels distort under load.

9.9 Calibration

9.9.1 The calibration of liquid column manometers, dial gages, and graduated scales or tape measures is not required for each test.

9.10 Procedure

9.10.1 Omit from the test specimen any unique influence from gravity, sealing, or construction material that does not occur during actual installation.

9.10.1.1 If the test panel orientation is either inverted or vertical, a gravity correction shall be made in the determination of the allowable superimposed loading. Tests run in an inverted position shall include data from pressure reversal or an upright specimen to demonstrate that unlatching will not occur in the normal orientation.

9.10.1.2 For negative load tests, the interior side of the specimen shall face the higher pressure. Support and secure the specimen by the same number and type of anchors normally used for installing the unit on a building, or if this is impractical, by the same number of other comparable fasteners located in the same way as in the intended installations.

9.10.1.3 If air leakage through or around the test specimen is excessive, tape or plastic film is acceptable to block any cracks and joints through which the leakage is occurring. Tape or film shall not be used to span a joint where it restricts differential movement between adjoining members. This caution applies specifically to the inside face of standing seam panels which tend to spread apart under pressure. See the instructions for proper film placement in the annex.

9.10.1.4 In cases in which it will not affect the results, it is permissible to apply a single thickness of polyethylene film no thicker than 6 mils (0.006 in.) (0.15 mm). The technique of application is important so that full load is permitted to be transferred to the specimen and the membrane does not prevent movement or failure of the specimen. Apply the film loosely, with extra folds of material at each corner and at all offsets, and recesses including the perimeter of the test specimen. The film shall not span any joint that will tend to separate under pressure. When the load is applied, there shall be no fillet caused by tightness of plastic film that will have a significant effect on the results.

9.10.2 Procedure - the following procedure is designed to produce a minimum of six points on the load-deflection curve. For precision in determination of the yield and ultimate strength, smaller increments are permitted to obtain additional points at the discretion of the test operator.

9.10.2.1 Check the specimen for proper adjustment, and close all vents in pressure-measuring lines.

9.10.2.2 Install the required deflection measuring devices at their specified locations.

9.10.2.3 At each increment of load, maintain pressure for not less than 60 seconds and until the dial gages indicate no further increase in deflection.

9.10.2.4 Apply a nominal initial pressure equal to at least four times but not more than ten times the dead weight of the specimen. If the applied loads are in the same direction as gravity on the test specimen, remove this pressure and record the initial reading at zero load. If applied loads are not in the same direction as gravity, use this nominal pressure as the reference zero and record the initial readings.

9.10.2.5 Unless otherwise specified, the first increment of load shall be nominally equal to one-third the anticipated ultimate load.

9.10.2.6 Reduce the pressure difference to zero and, after a recovery period of not more than 5 min at zero load, increase the pressure to reference zero (if used instead of zero) and take readings to determine permanent deformation for the first increment of load.

9.10.2.7 Proceed as above with successive increments that do not exceed one sixth the maximum specified test load until failure or the specified ultimate load is reached.

9.10.2.8 When the behavior of the specimen under load indicates that failure is imminent, it is permissible to remove the deflection measuring devices and to increase the load continuously until failure. In such cases, the yield point must be assumed to have been reached at or before the last recorded load.

9.10.2.9 After initial failure of one or more connections that leaves the majority of the specimen intact, it is permissible to provide external support to prevent further displacement of those locations and continue the loading to develop additional data.

9.11 Report

9.11.1 Report the following information:

9.11.1.1 Date of the test and issue of the report. State the location of the facility, name of the testing agency (if any), and names of the specific observers of the test. Cite the qualifications of any independent observers called in to certify the test procedure or results.

9.11.1.2 Identification of the specimen (manufacturer, source of supply, dimensions, model types, materials, and other pertinent information).

9.11.1.3 Detailed drawings of the specimen and test fixture, showing the dimensions of T125-profiles, purlin location, measurement locations, panel arrangement, installation and spacing of anchorage, sealants, and perimeter construction details. Note any modifications made on the specimen, including reinforcement in accordance with T125-9.10.2.9, to obtain the reported values, on the drawings.

9.11.1.4 Measured thickness and tensile yield strength of the material used in the test panels. Mechanical properties and thickness shall be measured after the removal of coatings in accordance with the appropriate standards for the material used, that is. Test methods A 370 for steel and method B 557 for aluminum. These values will be used to verify conformity with the product specification or make any required adjustment of allowable capacity within the range of a material specification and shall be made in accordance with the appropriate ASTM standard for the material involved.

9.11.1.5 Tabulation of the number of test load increments, zero load value and pressure differences exerted across the specimen at load increments, pertinent deflections at these pressure differences, and permanent deformations at locations specified for each specimen tested.

9.11.1.6 Plot of deflections and permanent set related to pressures applied.

9.11.1.7 Duration of the test loads including incremental loads.

9.11.1.8 Record of visual observations of performance and description of the location and type of failure experienced.

9.11.1.9 When the tests are made to check conformity of the specimen to a particular specification, an identification or description of that specification.

9.11.1.10 Statement that the tests were conducted in accordance with this test method or a full description of any deviations from this test method.

9.11.1.11 Statement that the panel and sealing method was observed by the testing engineer with comments concerning whether tape or file, or both, were used to seal against leakage, and whether, in the judgment of the test engineer, the tape or film could have influenced the results of the test.

9.11.2 If several essentially identical specimens of a component are tested, report the results for all specimens, with each specimen being identified properly, particularly with respect to distinguishing features or differing adjustments. A separate drawing for each drawing specimen will not be required if all difference between them are noted on the drawings provided.

9.12 Precision and Bias

9.12.1 This is a new procedure, and precision and bias of the test. Method is to be determined.

9.13 Keywords

9.13.1 Air bags, air seals, anchor strength, crosswise distortion; deflection; flexural capacity; rib spread; sheet metal roof and siding; single stain construction; standing seam; static air pressure; structural performance; test chamber; trapezoidal, ribbed, and corrugated panels; unlatching failure

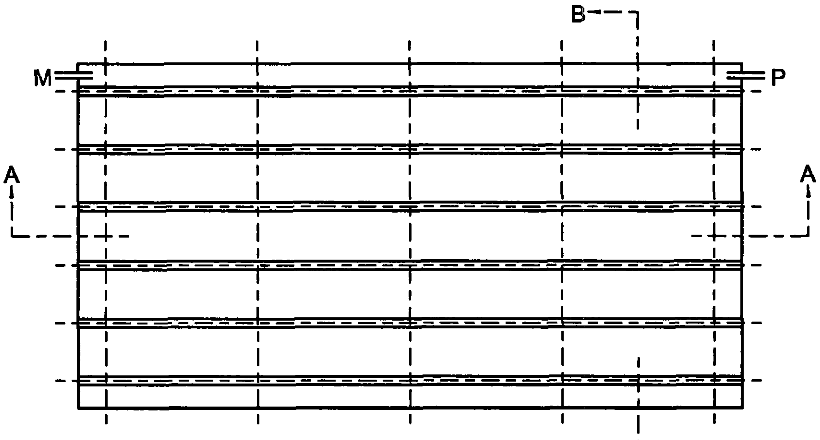
9.14 Proper Use of Film and Airbags

9.14.1 Where plastic film is used to seal joints to allow pressurization of the interior or underside surface of the roof specimen it shall contact all surfaces of the panel and shall not interfere with the air passage to the specimen or the movement of adjacent parts. Film shall not bridge or otherwise block the gap at the base of a standing seam, as in Figure T125-9-3. Such bridging or blocking prevents lateral movement and proper pressurization of the specimen and yields nonconservative results whether it be a flat film sealed at the edges or an air bag.

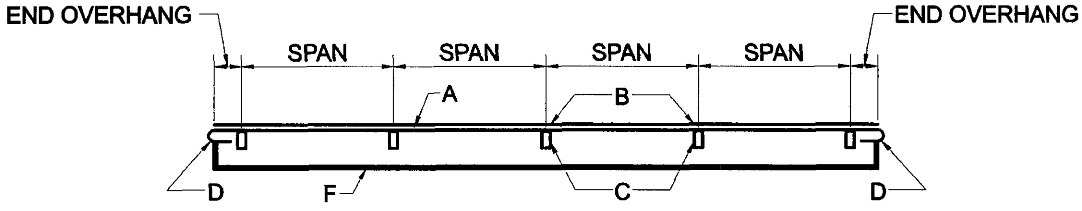
9.14.2 Longitudinal pleats that fit up into the rib on both sides of a clip, as in Figure T125-9-4 herein, ensure full contact and eliminate restraint.

9.14.3 Multiple longitudinal air bags wider than the panel module, as in Figure T125-9-5 herein, provide the same effect without the need to perforate the air bag with the anchor fastener. Where either of these interferes with proper clip engagement, all seals must be limited to the perimeter of the test specimen.

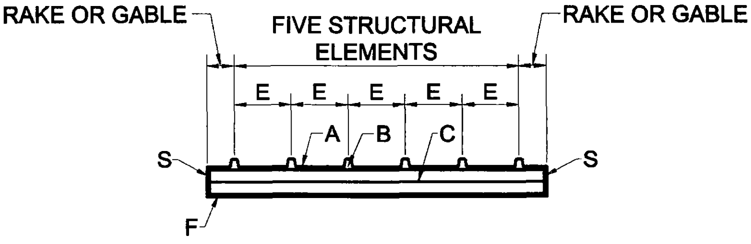
9.14.4 Multiple crosswise air bags, as in Figure T125-9-6 herein, do not make full contact and will hamper panel distortion. Plastic film must always lie between the panel and the crosswise support structure to provide continuous longitudinal contact. Other methods of sealing that demonstrate equivalent distortion as air pressure are acceptable.



PLAN VIEW



SECTION AA - PARALLEL TO PANEL LENGTH
(REFERENCE SECTION 7.2)



SECTION BB CROSSWISE TO PANEL LENGTH

FIGURE 9-1
SCHEMATIC OF TEST APPARATUS FOR ASTM E 1592 UPLIFT TESTING

A. Test Panels
B. Anchors
C. Crosswise Supports and Purlins
D. Flexible End Seal
E. Structural Element of Panel
F. Pressure or Vacuum Chamber
M. Manometer Locations
P. Air Supply or Exhaust
S. Flexible Side Seal

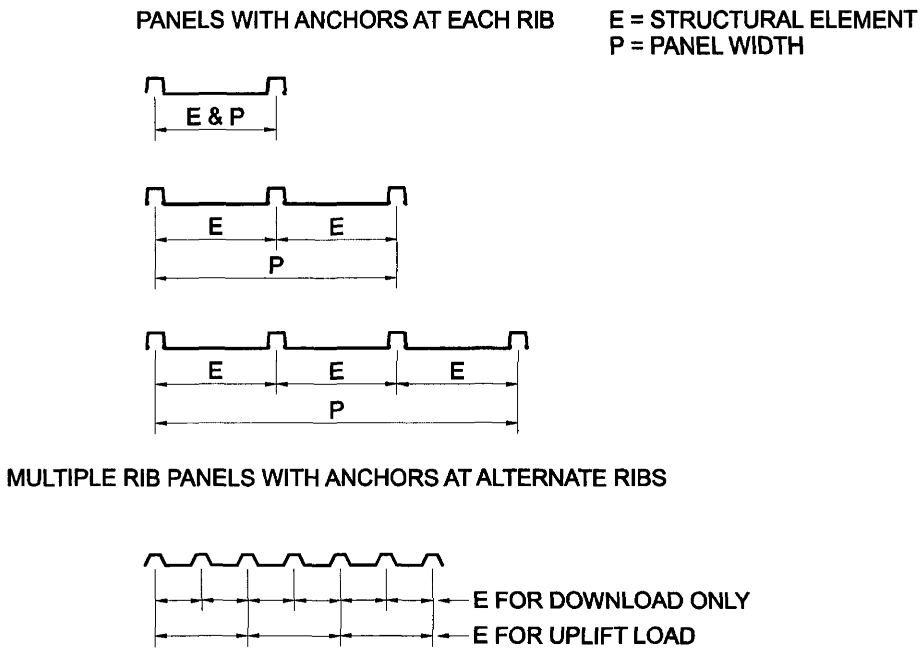


FIGURE 9-2
EXAMPLES OF STRUCTURAL ELEMENTS AND PANEL WIDTH FOR DIFFERENT PROFILES

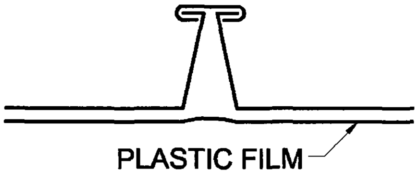


FIGURE 9-3
IMPROPER SEAL WHERE FILM SPANS CREVICE AT BASE OF RIB

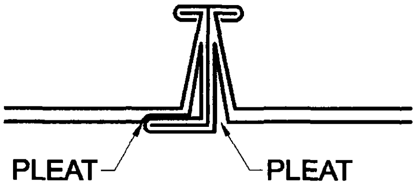


FIGURE 9-4
PLEATS MAKE CONTACT WITH METAL PANEL ON BOTH SIDES OF CLIPS

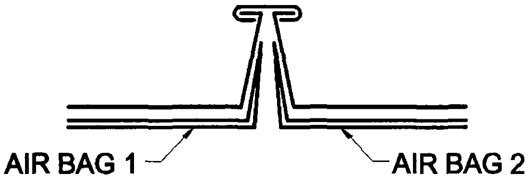


FIGURE 9-5
PROPER SEAL AT RIB WITH MULTIPLE LONGITUDINAL AIR BAGS

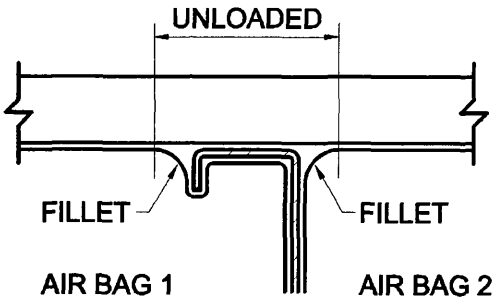


FIGURE 9-6
IMPROPER USE OF MULTIPLE AIR BAGS BETWEEN SUPPORT

TESTING APPLICATION STANDARD (TAS) 126-95

STANDARD PROCEDURES FOR ROOF MOISTURE SURVEYS

1. Scope:

1.1 This Protocol covers the procedures for non-destructive testing for the presence of moisture, and the subsequent destructive testing to confirm moisture content, in Roof System Assemblies; including insulation.

1.2 This Protocol applies to the testing of all Roof Systems Assemblies as required in Section 1521.12 of the *Florida Building Code, Building.*

1.3 All testing and calculations shall be conducted by an approved testing agency and all test reports, including calculations, shall be signed by a Professional Engineer or a Registered Roof Consultant.

2. Referenced Documents:

2.1 *The Florida Building Code, Building.*

2.2 *The Roof Consultants Institute*
Standard Practice for the Detection and Location of Latent Moisture in Building Roofing Systems by Nuclear Radioisotopic Thermalization

Glossary of Terms

2.3 *Third International Symposium on Roofing Technology - 1991*
New Wetting Curves for Common Roof Insulations

2.4 *ASTM Standards*

D 1864	Moisture in Mineral Aggregate Used on Built-Up Roofs
D 1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
E 380	Excerpts from Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.5 *NBS Building Science Series 131*
Laboratory Evaluation and Non-Destructive Methods to Measure Moisture in Built-Up Roofing Systems

3. Terminology & Units:

3.1 Definitions - For definitions of terms used in this Protocol, refer to: ASTM D 1079; Standard Practice for the Detection and Location of Latent Moisture in Building Roofing Systems by Nuclear Radioisotopic Thermalization (noted in Section 2.2, above); the RCI Glossary of Terms; and/or Chapter 2 and Section 1513 of the *Florida Building Code, Building.* Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Several pertinent definitions specific to this Protocol are listed below for reference.

3.2.1 *Core Cut* - A sample of the roof system extracted from an existing roof system for further analysis, including all elements of the roofing system and deck materials capable of moisture absorption, excluding light weight and structural concrete, light weight insulating concrete, gypsum, and cementious wood fiber roof decks.

3.2.2 *Equilibrium Moisture Content (EMC)*-The percent moisture content in a material after long term exposure to a given temperature and relative humidity. Sometimes referred to as constant weight.

3.2.3 *Film Badge* - A device which must be carried by users of nuclear measuring instruments to measure their total radiation exposure.

3.2.4 *Gravimetric Analysis* - The determination of moisture content by weight of a material by comparing the wet weight (W_w) to the dry weight (D_w) and applying the formula:

$$\% \text{moisture} = \frac{W_w - D_w}{D_w} \times 100$$

3.2.5 *Histogram* - A chart showing a distribution of data, e.g., the number of occurrences of a value plotted versus the value itself.

3.2.6 *Hydroscopic* - The term used to describe a material which attracts, absorbs and retains atmospheric moisture.

3.2.7 *Impedance* - The ratio of effective electromotive force to the effective current in an alternating-current circuit.

3.2.8 *Infrared Camera* - A device which is sensitive to thermal radiation of wavelengths longer than those of visible light.

3.2.9 *Moisture by Weight* - Weight of moisture content of a material compared to the dry weight of the material expressed in percentage.

3.2.10 *Radioisotopic Thermalization* - The process of reducing the energy of a neutron to a level where it is in equilibrium with its environment. Thermalization occurs when the energy of fast neutrons is partially absorbed by moderators of hydrogen atom collisions.

3.2.11 *Relative Moisture* - Moisture content without regard to absolute values (i.e. wet, wetter, wettest).

3.3 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Significance and Use:

4.1 The testing requirements outlined herein provide a means of: 1) establishing the criteria for testing for moisture trapped within Roof System Assemblies; and, 2) determining the percentage of moisture in specific areas and components as required in Section 1521.12 of the *Florida Building Code, Building.*

5. Applicable Roof System Assemblies:

5.1 All types of low slope Roof System Assemblies may be tested by one or more of the methods noted in Section 7.

5.2 Type of testing equipment may vary depending on the type of roof membrane. The equipment manufacturer shall be consulted for a listing of suitable membrane type for each type and model of testing equipment.

6. Precautions:

6.1 This Protocol may involve hazardous materials, operations, and equipment. While several safety issues are addressed in Section 9, this Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Equipment Types - Non-Destructive Testing:

7.1 Infrared Thermography

7.1.1 An infrared camera is used to detect the temperature of areas within a Roof System Assembly. As the air temperature decreases at sunset, dry insulation allows the roof surface above to cool quickly, while areas where moisture is present, either in the insulation or between membrane plys, have a large thermal mass and take much longer to cool.

7.1.2 The infrared camera is calibrated to an appropriate wavelength and is used to detect and record the difference in infrared radiation emitted from the roof surface.

7.1.3 Infrared scanning may be conducted on the roof surface or from the air. Aerial infrared photography is generally used to locate 'hot spots' for subsequent roof top scanning.

7.1.4 Infrared equipment can be a simple roof top scanner which records relative moisture or can record by film or video.

7.1.5 While infrared scanning provides accurate moisture content within a Roof System Assembly, a thorough examination of the structure should be conducted prior to scanning to determine whether one or more of the following conditions exist. These conditions could create inaccuracies during an infrared scan.

- underdeck heating or cooling units that may affect a limited area of the roofing above;
- venting of hot fumes which can cause 'hot trails';
- daytime shading caused by sunlight obstructions (i.e. trees, billboards, adjacent building, or intermittent clouds) of the roof surface causing uneven heat conduction;
- moisture on the roof surface;
- heavy gravel on the roof surface which may be obstructing roof top moisture; and,
- windy conditions at the roof top level potentially causing irregular infrared readings due to convection across the roof surface.

7.1.6 Infrared scanning is most effective at sunset or at night.

7.2 Nuclear Thermography

7.2.1 A nuclear scanning meter emits neutrons from a radiation source within the scanning meter downward to the Roof System Assembly. Neutrons which encounter hydrogen atoms are slowed down; a portion of which 'bounce back' to be counted by a detector within the scanning meter. Since water contains significant hydrogen atoms, areas of moisture within the roofing plys and/or insulation record high levels of slowed neutrons. The nuclear scanning meter provides accurate results to a depth of 7 in.

7.2.2 Nuclear testing is generally conducted on a 5' x 5' grid pattern over the entire roof surface. If moisture is detected within a particular 5' x 5' grid area, the area is reduced to 2' x 2' grid areas for greater accuracy in determining areas of moisture.

7.2.3 Varying types and thickness of membrane, and other roofing components, also contain varying quantities of hydrogen atoms and; therefore, higher levels can be detected at different areas. For this reason, operator skill and experience is important.

7.2.4 Ponded water will result in increased readings; however, the quantity of water below the scanning meter in these areas is generally constant. For this reason, areas of ponded water can be tested and compared separately.

7.2.5 Operators of nuclear equipment shall be licensed by the United States Nuclear Regulatory Commission (USNRC), or a State Agency which has entered into an agreement with the USNRC to assume control over distribution and use of equipment containing a radioactive element, to transport and operate nuclear testing equipment. Licensing requirements can differ depending on the radioactive element being used in the equipment.

7.2.5.1 Changes in State and Federal regulations pertaining to the purchase, distribution and use of equipment containing radioactive elements are common. It shall be the obligation of the user to keep up-to-date with all current regulations. The final responsibility for State and Federal compliance shall rest with the owner of the equipment.

7.2.6 The operator of any equipment containing an isotopic radioactive source consisting of Americium 241, Radium 226, or Cesium 137 with a Beryllium target shall be familiar with the device manufacturer's instruction manual and shall have completed an approved training program provided by the device manufacturer or other party acceptable to the appropriate licensing authority.

7.2.7 The device shall be stored in a locked area, base down, and in contact with shielding material such as concrete. Transportation shall be in a DOT approved shipping container, secured against removal by unauthorized personnel, and be accompanied by a current "Shipper's Certification For Radioactive Materials." During cleaning and use of the device, the operator shall avoid direct contact with the base of the instrument and shall make sure others do likewise.

7.2.8 Leak tests must be performed in accordance with the manufacturer's specifications, at prescribed intervals and in compliance with the procedures designated by the licensing authority.

7.2.9 All maintenance of the radioactive source or source holder, or other actions which entail removal of the source, shall be performed by the device manufacturer or other persons specifically trained to perform these operations.

7.2.10 All users shall be provided with film badge type dosimeters to be worn when handling or using the equipment. Authorized personnel shall see to it that other persons are kept away from the instrument during use, transportation or storage.

7.2.11 The device containing licensed material may be disposed of by either:

- transfer to another specifically licensed user or disposal agency; or,
- return to the device manufacturer.

7.3 Impedance Testing

7.3.1 An impedance meter emits low frequency electronic signals from rubber electrodes located on the base of the instrument. Over a dry substrate, the electrodes are insulated from one another, no complete circuit exists and little or no reading is recorded. Over a wet substrate, the electrical conductance is greater, which leads to a complete electrical circuit and readings are recorded. Greater amounts of moisture result in higher readings.

7.3.2 Meters are available in small, hand-held units and large, mobile units.

7.3.3 The impedance method of testing can only be used over a dry roof surface.

7.3.4 Modified instruments may be necessary for testing of EPDM Roof System Assemblies.

7.4 Selection of the type of nondestructive moisture testing to be conducted (infrared, nuclear or impedance) should be based on the parameters involved for the particular project. Regardless of which nondestructive test equipment is utilized, the results shall be confirmed through core sampling, as noted in Section 12, of both 'dry' and 'wet' areas.

8. Test Personnel:

8.1 All testing and core sampling shall be conducted under supervision of a Test Director who shall be thoroughly trained in the operation of the nondestructive moisture testing device used and who shall have a complete understanding of modern roofing technology, including the following:

- types of roofing membrane material, insulations, and decks and the effects of moisture in materials;
- construction procedures;
- equilibrium moisture contents;
- the effects of structural building components on testing results; and,
- moisture migration in building structures.

8.2 The Test Director shall have completed the following minimum training requirements:

- a recognized training program addressing radiological safety;
- operational training conducted by the manufacturer of the equipment being used;
- a formal training course addressing basic roofing technology offered by a recognized school or facility specializing in this course, evidence of the successful completion of which, via a certificate, diploma, or certification, shall be maintained by either that Test Director or his/her employer; and,
- previous field experience in this testing discipline with "hands on application," for a period of not less than five (5) years.

8.3 All other personnel involved in the survey shall have at least been instructed in radiological safety and basic roofing technology.

9. Safety:

9.1 Roof top testing requires constant monitoring of equipment in combination with movement on the roof top. All appropriate safety precautions shall be taken to provide a safe work area. It shall be the responsibility of the Test Director to establish a safety plan and convey the plan, in writing, to all roof top personnel. The safety plan shall include, but shall not be limited to the following:

9.1.1 Not less than two personnel shall be present on a roof top during testing. One person shall be designated as a 'spotter' to watch the operator and advise the operator of potential hazards.

9.1.2 All overhead wires, hot stacks or areas designated 'unsafe' shall be marked prior to testing.

9.1.3 All electric powered equipment shall be protected with 'in-line' ground fault interrupters not greater than 50 feet from the equipment.

9.1.4 Proper safety equipment and clothing shall be worn by all roof top personnel.

9.1.5 All roof top personnel operating nuclear measuring instruments shall carry a film badge to measure total radiation exposure.

10. Preparatory Procedures:

10.1 Prior to commencement of non-destructive testing, the user shall visit the job site to: 1) visually determine potential problem areas; 2) secure structural and roof plan drawings, if available; 3) verify composition of existing Roof System Assembly and associated Roofing Components; and, 4) solicit historical data pertaining to the Roof System Assembly and its performance. This information may be collected concurrently with the initial stages of the nondestructive testing.

10.2 Under no circumstances shall rooftop traffic be permitted until adequate data has been obtained to ensure the safety of the survey personnel.

10.3 A checklist shall be utilized to ensure that all necessary equipment, supplies and documentation are available and operational for the moisture survey.

11. Test Procedure:

11.1 A reference point and two dimensional axis system (x-axis and y-axis) shall be established on a field recording sheet for each roof deck. The field recording sheet shall include a sketch of the roof deck being surveyed. All measurements relating to grid markings (as noted in Section 11.2) and the location of roof top structures and equipment; roof penetrations; and/or membrane defects shall be made in accordance with this established reference point and axis system with horizontal distances measured along the x-axis and vertical distances measured along the y-axis.

11.2 The horizontal axis (x-axis) and vertical axis (y-axis) shall be broken into distance increments, creating an intersecting grid pattern for each roof deck to be surveyed. The distance between grid lines shall be determined by the Test Director to best provide an adequate number of readings for a thorough evaluation. Grid size will be influenced by the size and configuration of the roof deck and the material make up of the Roof System Assembly.

11.2.1 The distance between grid lines shall not exceed ten (10) feet.

11.2.2 The intersecting grid pattern shall only encompass the 'field' area of the roof, as noted in Section 11.3.

11.3 The reference point, axis system and associated grid pattern noted on the field recording sheet shall be marked on the roof surface and on wall flashings around the perimeter of the roof deck being surveyed for future reference. Ensure that the material used for marking is compatible with the surface material being marked.

11.4 All roof top structures, equipment, penetrations and obvious patched areas shall be noted on the field recording sheet.

11.5 All areas of ponded water shall be marked on the field recording sheet and all testing and analysis of these areas shall be conducted separately from other areas.

11.6 Areas where additional materials such as tapered edge insulation, cant strips and flashing materials are present shall be tested and analyzed separately to avoid unfounded comparisons of survey results. These areas of increased thickness will have differing results to those in the 'field' area of the roof and therefore shall be considered separately. These areas shall be marked on the field recording sheet.

11.7 Readings shall be taken at each grid intersection point or at regular, logical intervals and recorded on the field recording sheet. Additional readings shall be taken in areas adjacent to grid intersection points which exhibit elevated moisture content readings and at other locations as determined by the Test Director to provide a thorough examination of the roof deck being surveyed.

11.7.1 A smaller scale grid pattern may be created within an original grid area to accurately record the location of elevated moisture readings. The smaller scale grid pattern shall be noted on the data recording sheet and marked on the roof surface.

11.8 The following field conditions shall be considered when recording data.

11.8.1 Areas of increased material thickness due to extra bitumen or insulation materials, flashings and/or gravel may alter any established reference level.

11.8.2 A change in substrate material (e.g., metal vs. concrete decking; or, polyisocyanurate vs. fiberboard insulation) may alter any established reference level.

11.8.3 Heavy, moist, and/or dirty gravel may alter any established reference level.

11.8.4 Ponded water shall be avoided, if possible. If the device utilized is an impedance moisture meter, any ponded water shall be removed and the area allowed to dry prior to testing. All ponded areas shall be treated as separate roof areas and all testing and analysis of results shall be conducted separately, including separate core sampling.

11.8.5 Large grid sizes may result in undetected moisture. Grid sizes shall be established as small as possible.

12. Verification and Quantification:

12.1 All field data collected from non-destructive moisture testing is relative and must be quantified by core cuts.

12.2 Subsequent to non-destructive moisture testing, as noted in Sections 7 and 11, core samples, of minimum 2 in. diameter, shall be taken from: 1) those areas determined to be 'dry'; and, 2) those areas found to have varying levels of moisture present (i.e., 'low', 'medium' and 'high' levels) during non-destructive testing.

12.2.1 Sampling shall include cores from 'low level', 'medium level' and 'high level' readings taken during non-destructive testing for calibration purposes.

12.3 All samples shall be placed immediately into separate, watertight containers, such as plastic containers with airtight lids or plastic bags with sealable openings.

12.4 Each sample and the area on the roof from which it was taken shall be labeled for clear identification. Each area from which a core sample was taken shall be noted on the field recording sheet using the identification noted on the sample itself.

12.5 All roof areas from which core sample were taken shall be immediately repaired upon completion of the destructive testing

12.6 Samples, in their watertight containers, shall be immediately transported to an Approved Testing Facility for gravimetric analysis (moisture by weight testing) in compliance with ASTM Test Method D 1864.

12.6.1 The different components of the core sample shall be separated and tested separately. Each component shall be cleaned of debris and weighed immediately after removal from the watertight container and separation from other components of the sample. 'Wet' weights shall be recorded and tabulated in accordance with their respective labeling.

12.6.2 Samples shall be chamber dried for 24 hours at 230°F (114°C) and reweighed and the results recorded. After the second weight measurement, the samples shall be placed back into the drying chamber for one additional hour. At the completion of this one hour drying time, the samples shall be reweighed and the results recorded. This procedure shall be continued until no weight loss is recorded.

Note: Closed cell foam and expanded polystyrene insulation tend to dry slowly. The drying procedure, noted in Section 12.6.2, may require repeated cycles until a constant dry weight is recorded. Expanded polystyrene may required an oven temperature of 150°F (66°C) to avoid deterioration of the insulation.

12.6.3 Moisture by weight shall be determined for each tested component using the equation noted in Section 3.2.4.

12.7 Results from gravimetric analysis shall be used to calibrate the moisture readings taken during non-destructive testing, as noted in Section 13.2.

13. Analysis of Collected Data:

13.1 The interpretation of field recorded moisture levels and their correlation to moisture by weight of core sample results shall be accomplished by an individual trained in both the principles of roof system moisture surveys and the type of roof system being surveyed.

13.2 Once the actual moisture levels have been determined for the 'low', 'medium' and 'high' readings, a straight line graph shall be generated relating these field readings to actual moisture levels. This graph shall be used to convert field readings to quantitative measurements, such as percent moisture by weight.

13.3 Histogram

13.3.1 All quantitative data taken from the line graph shall be compiled in a histogram which groups the data points by defining intervals and combining all data points which fall within a particular interval.

13.3.2 Interval sizes shall be large enough to ease the computational task, but small enough to easily distinguish the normal distribution by the dry sections of the roof area.

13.4 Graphic Plot (Moisture Map)

13.4.1 Once wet and dry areas are defined in the histogram, a graph of the roof plan shall be drawn to summarize the survey. The moisture map shall be prepared depicting a minimum of three moisture levels, the lowest of which shall be the maximum allowable amount of moisture in a Roof System Assembly, as defined in Section 1521.12 of the *Florida Building Code, Building*. The moisture map may be prepared by a dedicated computer program or by hand contouring.

13.5 Statistic Analysis of Data

13.5.1 Statistically, the histogram will result in a bell curve, typically referred to as a 'normal distribution.' Two conditions must be met to produce a statistically meaningful curve:

- The material being tested (including deck type) must be of the same physical make-up; and,
- Enough data must be recorded to allow for normal distribution to appear.

13.5.2 The width of a normal distribution is determined by the 'standard deviation.' The importance of the standard deviation is that once the mean (average) and the standard deviation are known, the 'end points' of the normal distribution and; therefore, the count rate range for dry areas of the roof can be defined. Statistically, 99.7% of the measurement counts for the dry areas of the roof will fall between the three (3) standard deviation limits.

13.5.3 The normal distribution curve shall be overlaid on the measurement data histogram. To verify the end points for the overlay process, the mean and standard deviation shall be determined using the following equations:

$$Mean = \frac{(X_i \times F_i)}{N} \qquad \text{and,}$$

$$S_x = \sqrt{\frac{(X^2_i \times F_i) - \frac{(X_i \times F_i)^2}{N}}{N - 1}}$$

where,

X_i = the midpoint of the histogram interval;

F_i = frequency of occurrence;

N = total number of points; and,

S_x = standard deviation.

These equations are easily implemented with a programmable calculator or a small computer.

14. Report

14.1 The final moisture survey report shall include the following:

14.1.1 The job name, job site address and a description of the Roof System Assembly being tested. A description shall be provided for each roof deck tested.

14.1.2 The type of non-destructive testing conducted, including the type and manufacturer of the testing equipment.

14.1.3 A copy of the field recording sheet.

14.1.4 A copy of the core sample test report provided by the testing laboratory, including gravimetric results.

14.1.5 Analysis of data, including a histogram summarizing all data collected; a scaled graphic plot (moisture map) of the roof area depicting at least three (3) distinct moisture levels and including all roof top structures, equipment, drains, penetrations, areas of ponded water and precise locations of core cuts; and, the statistical analysis of data.

TESTING APPLICATION STANDARD (TAS) 131-95

STANDARD REQUIREMENTS FOR THERMOPLASTIC OLEFIN ELASTOMER BASED SHEET USED IN SINGLE-PLY ROOF MEMBRANE

1. Scope:

1.1 This Protocol covers unreinforced and reinforced thermoplastic olefin elastomer sheet made from blends of polypropylene and ethylene-propylene rubber (TPO), intended for use as a roof membrane exposed to the weather.

1.2 The test and property limits are used to characterize the membrane and are minimum values. In-place roof system design criteria, such as fire resistance, field seaming strength, material compatibility, and up-lift resistance, in situ shrinkage, among others, are factors which must be considered but are beyond the scope of this specification.

1.3 The following precautionary caveat pertains to the test methods portion only, Section 8, of this specification: This Standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.4 All testing shall be conducted by an approved testing agency, and all test reports shall be signed by an authorized signer of the testing/listing agency.

2. Referenced Documents:

2.1 *ASTM Standards*

D 412	Test Method for Rubber Properties in Tension
D 471	Test Method for Rubber Property - Effect of Liquids
D 573	Test method for Rubber-Deterioration in an Air Oven
D 624	Test Method for Rubber Property - Tear Resistance
D 751	Method of Testing Coated Fabrics
D 816	Methods of Testing Rubber Cements
D 1149	Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber (Flat Specimens)
D 1204	Test Method for Linear Dimensional Changes of Non-rigid Thermoplastic Sheeting or Film at Elevated Temperature
D 2137	Test Method for Rubber Property - Brittleness Point of Flexible Polymers and Coated Fabrics
G 26	Practice for Operating Light-Exposure of Nonmetallic Materials
G 53	Practice for Operating Fluorescent UV - Condensation (QUV)
D 1822	Tensile Impact Testing
E 96	Water Vapor Permeability, Method BW
E 380	Excerpts from Use of the International System of Units (SI) (The Modernized Metric System)

2.2 *The Florida Building Code, Building*

2.3 *Application Standards*

TAS 114	Test Procedures for Roof System Assemblies in the High Velocity Hurricane Zone Jurisdiction

3. Terminology & Units:

3.1 Definitions - For definitions of terms used in this Protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building* and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Limitations and Precautions:

4.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Classification:

5.1 Types are used to identify the principal polymer component of the sheet.

5.1.1 Ethylene-Propylene based elastomer (TPO)

5.2 Grades indicate the mass percentage of the polymer (TPO) in relation to the total sheet:

5.2.1 Grade 1 - Greater than 95%.

5.2.2 Grade 2 - 50 to 95%.

5.3 Class describes sheet construction.

5.3.1 Class U - Unreinforced.

5.3.2 Class SR - Reinforced, internally or externally.

6. Materials and Manufacture:

6.1 The sheet shall be formulated from the appropriate polymers and other compounding ingredients. The principal polymer used in the sheet shall be one of those listed in Section 5.1.1 in accordance with the percentages listed in Sections 5.2.1 and 5.2.2.

6.2 The sheet shall be capable of being bonded to itself for making watertight field splices and repairs, and the supplier or fabricator shall recommend suitable bonding methods and materials.

7. Physical Properties:

7.1 The test shall conform to the physical requirements prescribed in Table 1 of this Protocol.

8. Dimensions and Permissible Variations:

8.1 The width and length of the sheet shall be as published and tested for physical property values. The sheet width shall be as tested for system performance in compliance with TAS 114.

8.1.1 The width and length tolerance shall be + 3%, - 0%.

8.2 The published sheet thickness tolerance shall be +15%, -10% of the specified thickness, but in no case shall the thickness be less than the minimum listed Table 1 of this Protocol.

TABLE 1
PHYSICAL REQUIREMENTS FOR TPO ELASTOMER SHEETS

Physical Property	Grade 1 or 2 Class SR	Grade 1 or 2 Class U
Thickness (over scrim) in. (mm)	min. 0.015 (0.385)	NA
Thickness (overall) in. (mm)	min. 0.039 (1.0)	min. 0.039 (1.0)
Tensile Strength psi (MPa)	NA	min. 1740 (12.0)
Breaking Strength lbf (kN)	min. 225 (1.0)	NA
Elongation (ultimate) %	NA	min. 500
Elongation (at break) %	min. 15[1]	NA
Tensile set %	NA	max. 10
Tear Resistance lbf/in (kN/m)		min. 340 (60)
Tearing Strength lbf (N)	min. 55 (245)	NA
Brittleness Point °F(°C)	max. -49 (-45)	max. -30 (-34)
Ozone Resistance no cracks	pass	pass
After Heat Aging-(A.H.A.)		
Tensile Strength-A.H.A. psi (MPa)	NA	min. 1740 (120)
Breaking Strength-A.H.A. lbf (kN)	min. 225 (1.0)	NA
Elongation (ultimate)-A.H.A. %	NA	min. 500
Elongation (at break)-A.H.A. %	min. 15[1]	NA
Tear Resistance -A.H.A. lbf/in. (kN/m)	NA	min. 340 (60)
Linear Dimensional Change -A.H.A %	max. ± 2	max. ± 2
Weight Change -A.H.A %		max. ± 2
Water Absorption mass %	max. ± 4[2]	max. ± 2
Factory Seam Strength lbf/in. (kN/m)	min. 51 (9) or Sheet Failure	min. 51 (9) or Sheet Failure
Weather Resistance no cracks or crazing	pass	pass
After Accelerated Weathering-A.A.W.		
Tensile Strength-A.A.W. psi (MPa)	report	min. 1450 (10.0)
Elongation (ultimate)-A.A.W. %	report	min. 200 %
PRFSE-A.A.W. %	report	30.00
Static Puncture Resistance	report	report
Dynamic Puncture Resistance	report	report
Tensile Impact ft•lb/in^2 (kJ/m^2)		min. 21 (44)

[1] For reinforcing fabric only.

[2] Test performed on coating elastomer only.

9. Workmanship, Finish, and Appearance:

9.1 The sheet, including factory seams, if present, shall be water tight and free of pinholes, particles of foreign matter, undisbursed raw material, or other manufacturing defects that might affect serviceability. Excessive irregularities on the sheet surface shall not be acceptable (or portion thereof), then its rejection should be negotiated between supplier and buyer.

9.2 Edges of the sheets shall be straight and flat so that they may be seamed to one another without fishmouthing.

10. Test Methods:

10.1 *Thickness (over scrim)* - Appendix 'A' of this Protocol.

10.2 *Dimensions* - Test Method D 751

10.2.1 Testing shall be conducted after permitting the sheet to relax at 73°F (23°C) for 1 hour.

10.3 *Thickness (overall)* - Test Methods D 412 for Class U Sheet and D 751 for Class SR Sheet.

10.4 *Tensile Strength* - Test Method D 412, Die C for Class U Sheet.

10.5 *Breaking Strength* - Test Method D 751, Grab Method for Class SR Sheet.

10.6 *Elongation (ultimate)* - Test Method D 412, Die C for Class U Sheet.

10.7 *Elongation (at break)* - Test Method D 751, Grab method for Class SR Sheet.

10.8 *Tensile Set* - Test Method D 412, Method A, Die C, 50% elongation for Class U Sheet.

10.9 *Tear Resistance* - Test Method D 624, Die C for Class U Sheet.

10.10 *Tearing Strength* - Test Method D 751, Procedure B for Class SR Sheet.

10.11 *Brittleness Point* - Test Method D 746 or D 2137.

10.12 *Ozone Resistance* - Test Method D 1149.

10.12.1 Inspect at 7x magnification on specimens exposed to 1 x 10^{-5} psi (100 MPa) ozone in air at 100°F (38°C). For Class U Sheet, wrap around 3" (76.2 mm) mandrel for 166 hour exposure. For Class SR Sheets, use Procedure B.

10.13 *Heat Aging* - Test Method D 573.

10.13.1 Age sheet specimens at 240°F (115°C) for 670 hours.

10.14 *Linear Dimensional Change* - Test Method D 471.

10.14.1 Conduct test at 158°F (70°C) for 166 hours.

10.15 *Water Absorption* - Test Method D 471.

10.15.1 Conduct test at 158°F (70°C) for 166 hours.

10.16 *Factory Seam Strength* - Test Method D 816, Method B.

10.16.1 Modify procedure by cutting a 1 in. (25.4 mm) wide by 12 in. (304.8 mm) long sample across the lap seam. Place in jaws approximately 2 in. (50.8 mm) from edges of the overlap area and test at 2 in. per minute (50.8 mm/min.) claim for rehearing.

10.17 *Weather Resistance* - Practice G 26

10.17.1 Xenon-Arc shall be operated to the following conditions:

Filter Type:	borosilicate inner and outer
Exposure:	0.35 W/m^2 at 340 nm
Cycle:	690 min light, 30 min. light and water spray

Black Panel Temperature: 80 ± 3°C

Relative Humidity: 50 ± 5%

Spray Water: deionized

Specimen Rotation: every 250 hours

Exposure Time: 4000 hours

10.17.2 Specimens for exposure shall be mounted under no strain. The recommended specimen size is 2.75 in. x 8.0 in. (70 mm x 203 mm). After exposure, remove the specimens and inspect immediately. Strain Class U specimens 10% and visually inspect for cracks and crazing under 7x magnification.

10.18 Weather Resistance - Practice G 53

10.18.1 Operate to the following conditions:

Lamp Type: Fluorescent UVB-313 (UVB-B)

Test Cycle: 20 hours UV @ 80°C 4 hours condensate @50°C

Exposure: 2000 hours

10.19 Tensile Impact - ASTM D 1822 for Class U Sheet.

11. Inspection and Special Testing:

11.1 The manufacturer shall inspect and test his production to assure compliance of the product with this Protocol.

11.2 If the results of any tests do not conform to the requirements of this specification, retesting to determine conformity shall be performed as required by the Chief Code Compliance Officer.

12. Rejection and Resubmittal:

12.1 Failure to conform to any one of the requirements prescribed in this specification shall constitute grounds for suspension of a current Product Approval.

13. Product Marking:

13.1 The sheet shall be identified on the labeling in compliance with Section 1517 of the *Florida Building Code, Building*.

14. Certification:

14.1 Upon request of the Chief Code Compliance Officer, a manufacturer may be required to certify that the material was manufactured and tested in accordance with this Protocol. Additional testing for confirmation may be required by an approved testing agency.

15. Packaging and Package Marking:

15.1 The material shall be rolled on a substantial core and packaged in a standard commercial manner.

15.2 Shipping containers shall be marked with the name of the material, the stock and lot number.

TESTING APPLICATION STANDARD (TAS) 131-95
Appendix A

TEST PROCEDURE FOR THICKNESS MEASUREMENT OF COATING OVER CLASS SR OLEFIN ELASTOMER BASED SHEET ROOFING

1. Scope:

1.1 The procedure outlined in this Protocol Appendix provides a method for measuring the thickness of the coating over fiber backing or reinforcing fabric.

2. Measurement Method:

2.1 Principal

2.1.1 The thickness of coating material over fiber, fabric, or scrim can be observed with a standard microscope. Measurement is made with a calibrated eyepiece.

2.2 Apparatus

2.2.1 Microscope, 60x with reticule.

2.2.2 Light Source - If light source on the microscope is not adequate, a small high-intensity lamp may also be used.

2.2.3 Stage Micrometer, 0.001 in. (0.0254 mm) divisions.

2.3 Calibration Procedure

2.3.1 Place a standard reflectance stage micrometer in place of the specimen.

2.3.2 Position the reticle eyepiece and the micrometer such that the scales are superimposed. Focus the reticle by turning the eyepiece. Focus the specimen and reticle by turning the vertical adjustment knob.

2.3.3 Locate a point at which both scales line up. Count the number of micrometer divisions away. Measure to the nearest 0.0005 in. or 0.5 mil (0.0125 mm). The calibration may be optimized by increasing the number of divisions measured.

2.3.4 Repeat the calibration three times and average the results. A calibration example is given below.

2.3.5 Calibration Example

2.3.5.1 If four reticle divisions (RD) are found equal to 4.5 micrometer divisions (MD), then 1 RD = 0.001125 in. or 1.125 mils (28.6 mm) or the calibration factor.

2.4 Specimen Analysis:

2.4.1 Carefully center a sharp single edge razor or equivalent over the fiber intersections along the x-x axis.

2.4.2 Make a clean bias cut completely through the sheet.

2.4.3 Remove the razor-cut section and mount in common putty with the cut surface facing upward.

2.4.4 Observe the cut surface with the eyepiece reticle. Measure the thickness of the coating on either side of the thread intersection by counting the number of reticle divisions (to the nearest one-half division).

2.4.5 Sample three areas of the coatings and average the results.

3. Calculation and Report:

3.1 Multiply the number or reticle divisions representing the thickness of the coating by calibration factor. Report the average results from the areas of the coating to the nearest 0.005” or 0.5 mils (12.7 mm).

4. Precision:

4.1 Precision - Measurements are accurate to ± -0.005 in. or 5.0 mils (12.7 mm) when the thickness is about 0.020 in. or 20 mils (0.5 mm).

TESTING APPLICATION STANDARD (TAS) 132-95

STANDARD REQUIREMENTS FOR TESTING AND APPROVAL OF SEALANTS USED IN ROOFING

1. Scope:

1.1 This Protocol covers the procedures for testing of sealants used in roofing applications and the approval process for all products which have successfully met the test criteria.

1.2 All testing shall be conducted by an approved testing agency, and all test reports shall be signed by an authorized signer of the testing/listing agency.

1.3 This Protocol has not been contemplated to measure the performance of the sealants in conjunction with any particular Roof System Assembly.

2. Referenced Documents:

2.1 *The Florida Building Code, Building.*

2.2 *ASTM Standards*

C 661	Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer
C 679	Test Method for Tack-Free Time of Elastomeric Sealants
C 719	Test Method for Adhesion and Cohesion of Elastomeric joint Sealants Under Cyclic Movement
C 792	Test Method for Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Sealants
C 793	Test Method for Effects of Accelerated Weathering on Elastomeric Joint Sealants
C 794	Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
C 1021	Standard Practice for Laboratories Engaged in the Testing of Building Sealants
D 140	Standard Practice for Sampling Bituminous Materials
D 412	Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
D 624	Test Method for Rubber Property -Tear Resistance.
D 1079	Standard Definitions and Terms Relating to Roofing, Waterproofing and Bituminous Materials
D 1149	Test Method for Ozone Resistance
E 380	Excerpts from the Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)

2.3 *Application Standards*

TAS 110	Standard Requirements for Physical Properties of Roof Membranes, Insulation, Coatings and Other Roofing Components.

2.4 *Roof Consultants Institute*

Glossary of Terms

3. Terminology:

3.1 Definitions - For definitions of terms used in this Protocol, refer to ASTM D 16 and/or ASTM D 1079 and/or Chapter 2 of the *Florida Building Code, Building* and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Limitations and Precautions:

4.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this Protocol to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Sampling:

5.1 Unless otherwise noted in the specific ASTM Test Standard, sampling of all non-bituminous products under this Protocol shall be in compliance with ASTM C 1021. Particular reference is made to Subsection 5.2.1 of this ASTM Test Standard.

6. Materials and Manufacture:

6.1 *Composition* - Sealants shall consist of an elastomeric material that can be applied in a bead to create a homogenous sealant joint, such as, but not limited to:

- one-part, low modulus, neutral-curing silicone;
- one-part, architectural grade polyure-thane;
- one-part, architectural grade butyl rubber sealant;
- one-part, architectural grade poly sulfidel; or,
- acrylic.

7. Performance Requirements:

7.1 *Physical Properties* - Sealants products used in roofing shall be in compliance with the minimum physical property requirements listed below:

PHYSICAL PROPERTY REQUIREMENTS

Physical Property	Test Standard	Requirement
Joint Movement Capability	C 719	min. ± 25%
UV Resistance	C 793	Good
Heat Aging	C 792	Good
Modulus of Elongation	D 412	min. 50 psi
Tensile Strength	D 412	min. 125 psi
Elongation	D 412	min. 500%
Tear Strength	D 624	min. 25 pli
Peel Strength	C 794	min. 18 pli (aluminum) min. 16 pli (concrete) min. 18 pli (steel) min. 20 pli (vinyl) min. 20 pli (wood)
Shore 'A' Hardness	C 661	min. 30
Ozone Resistance	D 1149	Good

7.2 *Performance* - Sealant products used in roofing shall be in compliance with the minimum performance requirements listed below:

PERFORMANCE REQUIREMENTS

Performance Characteristic	Test Standard	Requirement
Shelf Life	see Section 7.2.1	min. 1 year
Tool/Work Time		min. 20-30 minutes
Tack Free Time	C 679	min. 2 hours
Curing Time @ 77° F (25°C)		2-14 days
Full Adhesion Development		14-21 days

7.2.1 *Shelf Storage Life* - One tube or container of sealant shall be stored for 12 months from the date of manufacture at 77° ± 2° F (25° ± 1.1° C) and a relative humidity of 50 ± 5% and then shall be tested to determine compliance with the requirements of Section 7.2.

7.2.2 Product shall be approved by the manufacturer for application in a temperature range of 40°F to 100°F (4.4°C to 37.8°C).

8. Installation:

8.1 Sealant shall be installed to create two-point adhesion. Bond breakers and backer rods shall be applied in compliance with manufacturer's instructions.

9. Packaged Material:

9.1 Packaged material shall be certified by the manufacturer to be in compliance with this specification and shall be labeled in compliance with Section 1517 of the *Florida Building Code, Building*. Product Approval documents shall be provided to the purchaser or end user upon request.

9.2 Shipping containers shall be marked with the name of the material, stock number, lot number, year of issue and quantity therein and the name of the manufacturer or supplier.

9.3 Packaging shall provide coverage for bead size, storage requirements, limitations of use, and safety precautions.

9.4 Not all sealants are compatible for all roofing materials and adjoining substrates. The Sealant manufacturer shall provide a Product Data Sheet detailing applicable use and non-compatible substrates.

9.4.1 Product Data Sheet shall also include detailed instructions for substrate adhesion tests.

9.4.2 Product Data Sheets shall note any substrates that require primer before sealant application. Product Data Sheets shall note the name of the primer used for a specific substrate.

10. Rejection and Reinspection:

10.1 The Building Code Compliance Office may periodically purchase commercial quantities of the approved product for testing at Approved Testing Agencies to confirm compliance with the provisions of this Protocol. Failure to meet the minimum requirements set forth in Section 5 shall constitute grounds for rejection of the lots and suspension of the Product Approval. In cases of rejection the Authority Having Jurisdiction shall request removal of the rejected lot number(s) from commercial sale.

10.2 The Chief Code Compliance Officer may, after rejection of one or more lots, require third party quality control inspection as a provision to lifting of Approval suspension.

10.3 Shipping containers shall be marked with the name of the material, the stock number, lot number, quantity therein, and the name of the manufacturer or supplier.

TESTING APPLICATION STANDARD (TAS) 135-95

STANDARD REQUIREMENTS FOR FIBERGLASS REINFORCED TILE, SHINGLES OR PANELS AND FIBER CEMENT SHINGLES, SHAKES OR PANELS

1. Scope:

1.1 This Protocol covers physical property requirements for fiberglass reinforced, composite tile, shingles or panels and non-asbestos, fiber cement shingles, shakes and panels.

Note: In addition to the requirements noted herein, reference shall be made to the appropriate Section(s) of TAS 110.

1.2 The designation of fiberglass reinforced composite products between tile, shingles or panels, and the corresponding test requirements thereof, shall be made by the Chief Code Compliance Officer.

1.3 The designation of non-asbestos, fiber cement products between shingles, shakes or panels, and the corresponding test requirements thereof, shall be made by the Chief Code Compliance Officer.

1.4 This Protocol specifically addresses laboratory testing of these products and does not provide guidance for actual field application. Field application of these products shall be in compliance with the manufacturer's Product Approval.

1.5 All testing shall be conducted by an approved testing agency and all test reports shall be signed by a Professional Engineer.

2. Referenced Documents:

2.1 *ASTM Standards*

C 1154	Terminology for Asbestos and Fibre-Cement
C 1185	Test Methods for Sampling and Testing Non-Asbestos Fiber-Cement Flat Sheet, Roofing and Siding Shingles, and Clapboards
C 1186	Specification for Flat Non-Asbestos Fiber-Cement Sheets
C 1225	Specification for Non-Asbestos Fiber-Cement Roofing Shingles, Shakes and Slates
D 412	Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
D 635	Test Method for Flammability of Self-Supporting Plastics
D 638	Test Method for Tensile Properties of Plastics
D 790	Test Method for Flexural Properties of Plastics
D 883	Definitions of Terms Relating to Plastics
D 1204	Standard Test Method for Linear Dimensional Changes of Nongrid Thermoplastic Sheeting or Film at Elevated Temperature
D 1494	Test Method for Diffuse Light Transmission Factor of Reinforced Plastic Materials
D 1929	Test Method for Self Ignition of Plastics
D 2583	Test Method for Indentation Hardness of Plastics by Means of a Barcol Impressor
D 2565	Practice for Operating Xenon-Arc Type Light-Exposure Apparatus With and Without Water for Exposure of Plastics

E 84	Test Method for Surface Burning Characteristics of Building Materials
E 96	Test Methods for Water Vapor Transmission of Materials
E 108	Test Methods for Fire Testing of Roof Coverings
E 380	Excerpts from Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)
G 23	Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials.

2.2 *The Florida Building Code, Building*

2.3 CGSB Standards

41-GP-6M Standard for Sheets, Thermosetting Polyester Plastics, Glass Fiber Reinforced

2.4 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions - For definitions of terms used in this Protocol, refer to Chapter 2 and Section 1513 of the *Florida Building Code, Building* and/or The RCI Glossary of Terms; and/or ASTM D 883; and/or ASTM C 1154. Definitions from the *Florida Building Code*, Building shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Limitations and Precautions:

4.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this Protocol to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7. Testing Requirements

7.1 Physical Properties - Fiberglass Reinforced, Composite Tile, Shingles or Panels

7.1.1 All fiberglass reinforced, composite tile, shingle or panel roofing components shall meet the physical property requirements noted in Table 1, below.

TABLE 1
PHYSICAL PROPERTY REQUIREMENTS FOR FIBERGLASS REINFORCED, COMPOSITE TILE, SHINGLES OR PANELS

Physical Property	Test Standard	Requirements
Thickness inches (mm)	See Section 7.1.2	+ 10% of that specified by manufacturer
Dimensions	NA	$+^{3}/_{16}$ in. width
inches (mm)		+ $^{3}/_{8}$ in. for length of that specified by manufacturer
Glass Content (mass %)	See Section 7.1.3	min. 25% (average of 5) min. 20% (individual)
Flexural Strength psi (MPa)	D 790 Procedure A	min. 20,300 (140) for 1830 g min. 25,375 (175) for 2440 g
Flammability inch/min (mm/min)	D 635	max. 2.0 (50.0)
Flame Spread Index ft•min (m•min)	E 84	report
Smoke Density (%)	E 84	report
Self Ignition	D 1929	report
Fire Resistance	E 108	min. Class 'B'
Hardness	D 2583	min. 45
Light Transmission (%)	D 1494	+ 10% of that specified by manufacturer
Water Absorption (%) *(24 hours @ 73.4°F)*	D 570	<0.25%
Accelerated Weathering	G 23 OR D 2565 (See Section 7.1.4)	no significant change in surface gloss or color and no fiberglass exposure and compliance with physical properties noted below
Before Accelerated Weathering-B.A.W.		
Tensile Strength-B.A.W. psi (MPa)	D 638	report
Elongation-B.A.W. %	D 638	report
After Accelerated Weathering-A.A.W.		
Tensile Strength-A.A.W. psi (MPa)	D 638 +	min. 95% of B.A.W.
Elongation-A.A.W. %	D 638	min. 80% of B.A.W.

7.1.2 *Thickness* - Measure the thickness of the smooth-finished panels perpendicular to the surface at the point of measurement with a thickness gauge to an accuracy of 0.0002 in. (0.025 mm).

7.1.2.1 For flat panels, make six measurements on each specimen as follows:

- one near the center of each end of the specimen; and,
- two near each side of the specimen, each one-third of the distance from each end.

7.1.2.2 For configured panels, make 18 measurements on each specimen as follows:

- six at the crest;
- six at the bottom of the valleys; and,
- six on the center of the web between the crest and the bottom.
- One set of measurements shall consist of one measurement each on a crest, web and bottom adjacent to one another.
- Make one set of measurements near the center of each end and two sets near each side, each one-third of the distance in from each end.

7.1.3 *Glass Content*

7.1.3.1 Test Specimens

- Take at least five test specimens from uniformly distributed parts of the sample, not contiguous to one another. Each specimen shall have a projected area not less than 10 in^2 (64 cm^2). The edges shall not be frayed.

7.1.3.2 Apparatus - The test apparatus shall consist of the following.

- an analytical balance;
- a dessicator;
- heat resistant, nonreactive crucibles; and,
- a muffle furnace with temperature controls.

7.1.3.3 Procedure

- Weight the specimen on the analytical balance in a previously weighed, ignited crucible to the nearest 3.5 x 10^{-5} oz (1 mg).
- Place the crucible and specimen in a cold muffle furnace and ignite to constant mass at 1200°F + 57°F (649°C + 14°C). Avoid higher temperatures to prevent fusion of the glass and the entrapment of un-

burned carbon particles. The ignition generally requires from 2 to 6 hours.

- At the end of the ignition, the glass fabric residue shall be entirely white as contrasted to various egress of gray when all carbon is not removed. Moreover, the glass fabric residue shall show no sign of fusion.
- Allow the residue and crucible to cool to room temperature in a dessicator and reweigh on an analytic balance.
- If calcium carbonate is present, react the residual material remaining in the crucible with an excess of a concentrated solution of ammonium carbonate. Evaporate the specimen to dryness at 176°F + 37°F (80°C + 3°C) to drive off the excess ammonium salt, then heat at 230°F + 37°F (110°C + 3°C) for 2 hours.
- Following the ammonium carbonate treatment, transfer the residue to a beaker and treat with a slight excess of 3 N hydrochloric acid at 194°F (90°C) for 3 to 5 minutes.
- Filter out the acid-insoluble residue and wash with boiling distilled water until free of chloride ion as determined by the silver nitrate test.
- Place the filter paper containing the acid-insoluble glass fiber residue in a crucible, burn off the paper, allow the crucible and specimen to cool to room temperature and weigh the crucible and specimen.
- Some of the glass dissolves in the acid, the amount depending on the type of glass and the specific procedure. For E glass in this particular procedure, about 8.5% of the glass dissolves.

7.1.3.4 Calculations

- Calculate the glass content (G), as follows:

$$G = \frac{W_2}{W_1} \times 100$$

where,

G = glass content (% by mass);

W_1 = original mass of specimen; and,

W_2 = mass of residue from calcination.

Note: The mass loss is equal to the mass of the resin, the volatilized or decomposed pare of the fiber finish, and carbon dioxide evolved from tech dissociation of any calcium carbonate filler that may be present. Other incombustible fillers are included in the residue by tech procedure, and in these cases the glass content values are high.

- Calculate the E glass content, corrected for any calcium carbonate filler that may be present (G_c) as follows:

$$G_c = \frac{W_3}{0.915} \times \frac{100}{W_1}$$ where,

G_c = corrected glass content (% by mass);

W_3 = mass of residue after ammonium carbonate and hydrochloric acid treatments; and,

W_1 = original mass of specimen.

7.1.3.5 If no calcium carbonate is present, use G. If calcium carbonate is present, use G_c.

7.1.4 Prior to subjecting test specimens to accelerated weathering in compliance with ASTM G 23 or ASTM D 2565, specimens shall be tested for tensile strength and percent elongation in compliance with ASTM D 638, the results of which shall be reported. Subsequent to accelerated weathering, specimens shall be re-tested for tensile strength and percent elongation, the results of which shall be not less than 95% and 80% of the pre-weathering valves, respectively.

7.2 Physical Properties - Fiber Cement Shingles, Shakes or Panels

7.2.1 All fiber cement shingle, shake or panel roofing components shall be tested in compliance with ASTM C 1225, meeting the physical property requirements noted in Table 2, below.

7.2.2 Tests noted in Table 2 are broken into three sets of tests, the first two of which entail consecutive testing to determine the effects of heat/rain and freeze/thaw on a particular property and the last of which are separate tests.

7.2.3 *Sampling* - Sampling shall be in compliance with Section 4 of ASTM C 1185.

7.2.4 *Inter Laminar Bond Test* - Fiber cement product shall meet the requirements noted in Test Set #2 in Table 1, above, when subjected to inter laminar bond testing as follows.

7.2.4.1 Apparatus

- Two round steel plates having 2.5 in. (63 mm) diameter fitted with device for attachment to tensile tester.
- Tensile tester capable of providing separation rate not less than 0.5 inch per minute.
- Load cell or other load measuring device capable of recording loads up to 1000 lbf.
- Epoxy cement compatible with the fiber cement product being tested.

7.2.4.2 Test Specimens

- Prepare four 3 in. x 3 in. (76 mm x 76 mm) specimens with each specimen coming from different product units.
- Bond the 2.5 in. diameter steel

plates to the center of the test specimen on opposite sides and allow to cure for not less than 12 hours.

7.2.4.3 Test Procedure

- Mount the test specimen, with steel plates bonded on opposite sides, in the tensile tester and apply tensile load at a rate of 0.5 inch per minute.
- Observe the test specimen for failure and record the load from the

TABLE 2
PHYSICAL PROPERTY REQUIREMENTS FOR FIBER CEMENT SHINGLES, SHAKES OR PANELS

Physical Property	Test Standard	Requirement
Test Set #1 (Consecutive Testing of Four Specimens)		
Flexural Strength (Saturated Modulus of Rupture psi (MPa)	C 1185 Section 5	min. 798 (5.5) *(for primary strength direction)* and min. 50% of primary strength dir. *(for weak strength direction)*
Heat/Rain (50 cycles)	C 1185 Section 14	no cracks or structural alteration such to affect performance in use
Flexural Strength-after heat/rain (Saturated Modulus of Rupture) psi (MPa)	C 1185 Section 5	min. 798 (5.5) *(for primary strength direction)* and min. 50% of primary strength dir. *(for weak strength direction)*
Freeze/Thaw (50 cycles)	C 1185 Section 12	R>0.90 *(for both primary and weak strength directions)*
Test Set #2 (Consecutive Testing of Four Specimens)		
Inter Laminar Bond lbf (N)	See Section 7.2.4	min. 650 (2891)
Heat/Rain (50 cycles)	C 1185 Section 14	no cracks or structural alteration such to affect performance in use
Inter Laminar Bond-after heat/rain lbf (N)	See Section 7.2.4	min. 650 (2891)
Freeze/Thaw (50 cycles)	C 1185 Section 12 *(Substitute Inter Laminar Bond Test Noted in Section 7.2.4 for the Flexural Strength Test Noted in Section 12 of C 1185)*	R>0.90 *(R = ration of inter laminar bond after freeze/thaw to that prior to freeze/thaw)*
Test Set #3 (Separate Testing)		
Density lb/ft^3 (kg/m^3)	C 1185 Section 6	compliance with value stated by manufacturer
Water Absorption mass %	C 1185 Section 9	30% to 90%
Moisture Content %	C 1185 Section 10	compliance with value stated by manufacturer
Length and Width inches (mm)	C 1185 Section 7.6	max. variation of ±$^1/_4$ in. (± 6 mm) from nominal
Thickness inches (mm)	C 1185 Section 7.3	max. variation of −10% or +25% from nominal
Water Tightness (report)	C 1185 Section 11	no formation of droplets
Warm Water Resistance (report)	C 1185 Section 13	no cracks or structural alteration such to affect performance in use
Fire Resistance	E 108	min. Class 'B'

load measurement device at which failure occurs.

- Repeat the test for each of four test specimens and report the mean failure load.

7.3 Wind Driven Rain Testing

7.3.1 All fiberglass reinforced, composite tile, shingle or panel Roof Systems Assemblies and non-asbestos, fiber-cement shingle, shake or panel Roof System Assemblies shall be tested for resistance to wind driven rain in compliance with TAS 100 on all applications.

7.4 Uplift Resistance - Fiberglass Reinforced Tile or Fiber Cement Shakes

7.4.1 All fiberglass reinforced tile or fiber cement shake Roof System Assemblies shall be tested for static uplift resistance in compliance with:

- TAS 102 for mechanically attached components; or,
- TAS 102(A) for mechanically attached, clipped components.

7.4.2 Static uplift resistance testing shall be performed for each method of component attachment which the applicant wishes to include in the Roof System Assembly Product Approval (i.e., one nail, two nails, one screw, two screws, one nail with clip, one screw with clip, various clips, etc.).

7.4.3 Static uplift resistance testing shall be performed for each method of application which the applicant wishes to include in the Roof System Assembly Product Approval (i.e., counter-battened, direct deck and/or horizontal battened applications).

7.4.4 Fiberglass reinforced tile may be tested as 'Moment Based System' or 'Uplift Based System,' as defined in TAS 102 and TAS 102(A), depending on:

- whether the system is an air permeable system and meets the size constraints for wind tunnel testing set forth in TAS 108; and,
- if the conditions noted above are met, whether the system has been tested for wind tunnel testing, in compliance with TAS 108, resulting in an aerodynamic multiplier (l) for the particular fiberglass reinforced tile profile.

These options are further discussed in Section 4 of TAS 102 and TAS 102(A).7.4.4. All fiber cement shakes shall be tested as 'Uplift Based System' as defined in TAS 102 and TAS 102(A).

Notes:

1. The *Florida Building Code, Building* requires counter-batten applications for mechanically attached systems installed at roof pitches less than 4 i.:12 in. and horizontal batten applications for roof pitches in excess of 7 in:12 in.
2. The *Florida Building Code, Building* requires a clip on all eave components.

7.5 Uplift Resistance - Fiberglass Reinforced or Fiber Cement or Panels

7.5.1 All fiberglass reinforced or fiber cement panel Roof System Assemblies shall be tested for uplift pressure resistance in compliance with ASTM E 330.

7.5.2 Uplift pressure resistance testing shall be performed for each method of component attachment which the applicant wishes to include in the Roof System Assembly Product Approval.

7.5.3 Uplift pressure resistance testing shall be performed for each method of application which the applicant wishes to include in the Roof System Assembly Product Approval (i.e., counter-battened, direct deck and/or horizontal battened applications).

7.5.4 A 2:1 margin of safety shall be applied to all uplift pressure resistance results.

TESTING APPLICATION STANDARD (TAS) 138-95

STANDARD REQUIREMENTS FOR ALUMINUM PIGMENTED EMULSIFIED ASPHALT USED AS A PROTECTIVE COATING FOR ROOFING

1. Scope:

1.1 This Protocol covers aluminum pigmented emulsified asphalt suitable for application as a protective coating for built-up roofs and other exposed surfaces by brush, roller or spray application.

1.2 All testing shall be conducted by an approved testing agency and all test reports shall be signed by an authorized signer of the testing agency and/or Professional Engineer.

2. Referenced Documents:

2.1 *ASTM Standards*

B 209	Specification for Aluminum and Aluminum-Alloy Sheet and Plate
D 16	Terminology Relating to Paint, Varnish, Lacquer and Related Products
D 562	Standard Test Method for Consistency of Paints Using the Stormer Viscometer
D 1079	Definitions of Terms Relating to Roofing, Waterproofing, and Bituminous Materials
D 2824	Specification for Aluminum-Pigmented Asphalt Roof Coatings
D 2939	Standard Test Method of Testing Emulsified Bitumens Used as Protective Coatings
D 4798	Standard Test Method for Accelerated Weathering Test Conditions and Procedures for Bituminous Materials (Xenon - ARC Method)
D 4799	Standard Test Method for Accelerated Weathering Test Conditions and Procedures for Bituminous Materials (Fluorescent UV and Condensation Method)
E 380	Excerpts from Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)
G 26	Standard Test Method for Practice for Operating Light - Exposure Apparatus (Xenon - ARC Type) With and Without Water for Exposure of Non-metallic Materials
G 53	Standard Test Method for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Non-metallic Materials

2.2 *The Florida Building Code, Building*

2.3 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions - For definitions of terms used in this Protocol, refer to ASTM D 16; and/or ASTM D 1079; and/or Chapter 2 of the *Florida Building Code, Building* and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Limitations and Precautions:

4.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this Protocol to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

4.2 The user is cautioned that aluminum pigmented emulsified asphalt may generate a reaction resulting in the evolution of Hydrogen gas. Use caution when opening containers.

5. Sampling:

5.1 Sampling shall be in compliance with requirements set forth in ASTM D 2939.

6. Materials and Manufacture:

6.1 Aluminum pigmented emulsified asphalts covered by this Protocol are of general types such as:

6.1.1 Type I Nonfibrated

6.1.2 Type III Fibrated (containing no asbestos fiber)

6.2 *Composition* - The aluminum pigmented emulsified asphalt shall conform to composition requirements as follows:

COMPONENT PROPERTY	TEST STANDARD	ALL TYPES	
		Min.	Max
Weight per U.S. Gallon, (lbs.)	D 2939 Section 5	8.4	10
Weight per Liter, (g)	D 2939 Section 5	1,008	1,200
Residue by Evaporation (mass %)	D 2939 Section 8	30	—
Water Content (volume %)	D 2939 Section 11	—	70.00
Consistency, 77°F (25°C), Krebs units (Ku)	D 562 Procedure A or B	50	125

7. Performance Requirements:

7.1 Physical Properties - The aluminum pigmented emulsified asphalt shall conform to physical property requirements as follows:

PHYSICAL PROPERTY	REFERENCE SECTION	ALL TYPES	
		Min.	Max
Reference, initial (%)	See Section 8.1	50	—
Reflectance, 500 hours, (% retained)	See Section 8.4.5	90	—
Firm Set, (hours)	See Section	—	24
Resistance to Water	See Section 8.3	No blistering, no reemulsification	

7.2 *Uniformity* - After a thoroughly stirred sample has stood for 72 hours at room temperature 77° ± 2.0°F (25° ± 1.1°C) the aluminum emulsion shall be of smooth, uniform consistency without separation or settlement in storage to the extent that it cannot be readily dispersed by moderate stirring.

7.3 *Workability* - The aluminum pigmented emulsified asphalt shall be of suitable consistency for application above freezing by brush, roller, or suitable spray equipment without thinning with water or heating, and shall bond to either damp or dry surfaces to produce a film in which the aluminum pigment forms a bright reflective surface on smooth surfaced emulsion, sheet metal, conventional BUR and modified bitumen systems when applied according to manufactures recommendations.

7.4 Application of the aluminum pigmented emulsified asphalt shall be between 50°F (10°C) and 100°F (37.8°C) surface temperature. At temperatures above 100°F (37.8°C), a fine water mist to aid cooling of the roof surface to be coated prior to application is recommended.

7.5 The product is not intended for use where ponding water conditions exist.

8. Test Methods:

8.1 *Reflectance* - Test Method D 2824, Section 8.6

8.2 *Firm Set* - Test Method D 2939, Section 14

8.2.1 No reference lines shall be drawn across the faces of the panel.

8.2.2 Cure period shall be 24 hours.

8.3 *Resistance to Water* - Test Method D 2939, Section 17, Alternative B (17.3)

8.4 *Accelerated Weathering* - Test Method G 53 or G 26 (Test Method A)

8.4.1 Apparatus

8.4.1.1 For information on the test apparatus, refer to Section 9 of this Protocol.

8.4.2 Procedure

8.4.2.1 Thoroughly stir the sample to homogeneity. Clean the aluminum panels with industrial grade 1,1,1 trichloroethane, xylol, or an aliphatic solvent such as hexane followed by acetone prior to preparation of test specimens.

8.4.2.2 Prepare two (2) test specimens by spreading with a spatula through masks centered over two (2) metal, aluminum or aluminum alloy panels as described in Table 2 of Specification B 209 under alloy 3003-H14. Doctor off the excess level with a flat scraper. The mask shall have openings $2^1/_2$ by $4^1/_8$ in. (63.5 by 104.8 mm). The wet film thickness of non fibrated coating shall be 0.015 in. (0.38 mm) and fibrated coating shall be 0.020 in. (0.51 mm). Allow specimens to dry 48 hours at room temperature of 75.0° ± 3.0°F (23.9° ± 1.7° C).

8.4.2.3 Measure the initial percent luminous reflectance of each panel using Test Method D 2824, Section 8.6.

8.4.2.4 Place the coated panels into the weatherometer immediately after reflectance measurements.

8.4.2.5 Specimens shall always be placed in the QUV/Condensation chamber during the UV cycle.

8.4.2.6 Specimens shall always be placed in the Xenon-ARC during the 'Light Only Time.'

8.4.3 Evaluation Test Results

8.4.3.1 Inspect specimens at the end of a daily cycle during the UV period when the panels are thoroughly dry.

8.4.3.2 If using Xenon-ARC Method inspect specimens at the end of a complete cycle, 24 hours, during the light only period when the panels are thoroughly dry.

8.4.3.3 Periodically during, and at the conclusion of 500 hours, visually inspect specimens to determine physical changes. Accelerated weathering at 500 hours shall be as prescribed in Section 8.4, herein.

8.4.3.4 Repeat reflectance measurement as in Section 8.4.2.3, herein.

8.4.4 Accelerated Weathering Failures

8.4.4.1 *Cracking* At no time during the exposure cycles shall the film exhibit surface cracking as determined by viewing the weathered area through a microscope at 40x magnification.

8.4.4.2 *Sagging/Sliding* At no time during the exposure cycles shall the film show any signs of sagging or sliding beyond the exposed area of the draw down.

8.4.4.3 *Loss of Adhesion* Adhesion to the aluminum panels shall be maintained at 100 percent during the exposure cycles.

8.4.4.4 *Blistering* At no time during the exposure cycles shall the film exhibit development of blistering.

8.4.4.5 *Loss of Reflectance* At the conclusion of 500 hours exposure, the cured film shall maintain 90 percent of initial reflectance.

8.4.5 Reflectance Retained Calculation

8.4.5.1 Calculate the % reflectance retained after 500 hours as follows:

$$\%\ retained = \left(\frac{A}{B}\right) \times 100$$

where,

A = reflectance at 500 hours; and,
B = initial reflectance

8.4.6 Report

8.4.6.1 Designate the failure end point of the specimens as the exposure hours where cracking, sagging, sliding, loss of adhesion, blistering, or loss of more than 10% of initial reflectance first occurred.

9. Apparatus:

9.1 Operating light and water exposure apparatus (Fluorescent, UV Condensation Type) for Exposure of Nonmetallic Materials as described in Section 6 of Recommended Practice G 53. Unless otherwise specified, the lamps shall be UV-B lamps with a peak emission at 313 nm and a spectral energy distribution as shown in Figure 1 of Recommended Practice G 53.

9.2 Calibration and Standardization, G 53, Section 8.

9.3 Procedure, G 53, Section 9.

9.4 Test Conditions.

9.4.1 Unless otherwise specified, the apparatus shall be operated 7 days each week, two cycles per day, according to the following schedule. Each cycle shall consist of the following:

Exposure Type	Hours	Exposure Temperature
Ultra Violet (UV)	8	140.0°F ± 3°F (60°C ± 1.7°C)
Condensation	4.00	122.0°F ± 3°F (50°C ± 1.7°C)

9.5 Xenon-Arc Type as described in Section 6 of Procedure of Practice G 26, Test Method A.

10. Package and Package Marking:

10.1 Packaged material shall be certified by the manufacturer to be in compliance with this specification and shall be labeled in compliance with Section 1517 of the *Florida Building Code, Building*. Product Approval documents shall be provided to the purchaser or end user upon request.

10.2 Shipping containers shall be marked with the name of the material, stock number, lot number, year of issue and quantity therein and the name of the manufacturer or supplier.

11. Rejection and Reinspection:

11.1 The Authority Having Jurisdiction may periodically purchase commercial quantities of the approved product for testing at Approved Testing Agencies to confirm compliance with the provisions of this Protocol. Failure to meet the minimum requirements set forth in Sections 6 and 7 shall constitute grounds for rejection of the lots and suspension of the Product Approval. In cases of rejection the Chief Code Compliance Officer shall request removal of the rejected lot number(s) from commercial sale.

11.2 The Chief Code Compliance Officer may, after rejection of one or more lots, require third party quality control inspection as a provision to lifting of Approval suspension.

11.3 Shipping containers shall be marked with the name of the material, the stock number, lot number, quantity therein, and the name of the manufacturer or supplier.

TESTING APPLICATION STANDARD (TAS) 139-95

STANDARD REQUIREMENTS FOR WHITE ROOF PATCH SPECIFICATION

1. Scope:

1.1 This Protocol covers water-based elastomeric white roof patch with short bristle brush or trowel consistency.

1.2 The Protocol is provided as a guide for the selection of and proper use of white roof patch.

1.3 The Protocol specifically addresses laboratory testing of these coatings and does not provide guidance for actual field application.

1.4 All testing shall be conducted by an approved testing agency and all test reports shall be signed by an authorized signer of the testing agency and/or Professional Engineer.

2. Referenced Documents:

2.1 *ASTM Standards*

C 834	Standard Specification for Latex Sealants
D 16	Terminology Relating to Paint, Varnish, Lacquer and Related Products
D 412	Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
D 1079	Definition of Terms Relating to Roofing, Waterproofing, and Bituminous Materials
D 2196	Standard Test Methods for Rheological Properties of Non-Newtonian Material by Rotational (Brookfield) Viscometer
D 1475	Density of Paint, Varnish, Lacquer and Related Products
D 2824	Standard Specification for Aluminum-Pigmented Asphalt Roof Coatings
D 2939	Standard Test Methods for Emulsified Bitumens Used as Protective Coatings
E 380	Use of the International System of Units (SI) (The Modernized Metric System)
G 26	Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials

2.2 *The Florida Building Code, Building*

2.3 *Application Standards*

TAS 143	Standard Requirements for White Elastomeric Roof Coatings Used for Coating Built Up Roofs and Metal Roofing Systems

2.4 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions - For definitions of terms used in this Protocol, refer to ASTM D 16 and/or ASTM D 1079 and/or Chapter 2 of the *Florida Building Code, Building* and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Limitations and Precautions:

4.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this Protocol to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Materials and Manufacture:

5.1 The patch shall be one component, water based, white elastomeric material, suitable for application by short bristle brush or trowel without heating or thinning.

5.2 The patch shall be suitable for the application intended to adhere on a clean, dry, properly prepared, built-up roofing, metal, concrete, polyurethane foam, roof flashing and wood. The patch is not intended for use where ponding water conditions exist.

5.3 White roof patch has been formulated and designed to repair roof cracks and holes less than $^1/_4$ in. in width and it is recommended to be used in combination with White Elastomeric Roof Coatings as a top finishing coat.

5.4 The patch shall be suitable for application where sunlight and surface and ambient temperatures of 50°F or above and rising are maintained long enough for the patch application to cure.

5.5 *Composition* - The water-based elastomeric white roof patch product shall conform to composition requirements as follows:

Component Property	Test Standard	Requirement
Weight per U.S. Gallon, (lb)	D 1475	min. 11.0
Solids, (% by Weight)	D 2939 Section 8	min. 55.0

6. Performance Requirements:

6.1 *Physical Properties* - The water-based elastomeric white roof patch product shall conform to physical property requirements as follows:

Physical Property	Reference Section	Requirement
Viscosity, (CPS)	See Section 7.2	min. 30,000
Elongation, (%)	See Section 7.3	min. 150
Tensile Strength, (psi)	See Section 7.4	min. 150
Reflectance	See Section 7.5	min. 75
Accelerated Weathering	See Section 7.6	1000 hours no visible sign of cracks
Firm Set	See Section 7.7	24 hours
Resistance to Water	See Section 7.8	24 hours

7. Test Methods:

7.1 Preparation of Test Specimens - unless otherwise noted, test specimens shall be prepared as follows.

7.1.1 Dry films are prepared by applying one coat to release paper or glass to give a total dry film thickness of 25-27 mils (50 wet mils thickness is suggested).

7.1.2 The film is allowed to cure at 77°F (25°C) and 50% relative humidity for 48 hours, then dry the film in the forced draft oven at 140°F (60°C) for 24 hours.

7.1.3 The dried films are ready when they reach a constant weight at the one hour interval.

7.2 *Viscosity* - Test Method D 2196

7.2.1 Brookfield viscometer, #6D 20 RPM RVF Viscometer

7.3 *Elongation* - Test Method D 412 (Instron or equivalent) except as noted below.

7.3.1 Prepare test specimens as noted in Section 7.1 of TAS 143.

7.3.2 Cut specimens in type "C" die dumb bell shape.

7.3.3 Test type or functional equivalent at 77°F (25°C) and 50% relative humidity.

Cross head speed	2.0 in. per min.
Calibration prior testing	0.0 in. per min.
Gauge length	3.0 in. opening

7.3.4 Calculate percent elongation (E) in compliance with the following equation:

$$E = \left(\frac{L - L_0}{L_0} \right) \times 100$$

where,

E = percent elongation (%);

L = sample length at break (in.); and,

L_o = gage length (in.)

7.4 *Tensile Strength* - Test Method D 412, except as noted below.

7.4.1 Prepare test specimens as noted in Sections 7.3.1 through 7.3.3 herein.

7.4.2 Tensile strength in pounds/inch^2 = $\frac{f}{w}$

where:

f = the force at break in pounds;

w = sample width in inches; and

t = sample thickness in inches.

7.5 *Reflectance* - Test Method D 2824, Section 8.6

7.6 *Accelerated Weathering* - Test Method G 155

7.7 *Firm Set* - Test Method D 2939, Sections 13 & 14

7.8 *Resistance to Water* - Test Method D 2939, Section 17, ALT: A

8. Packaged Material:

8.1 Packaged material shall be certified by the manufacturer to be in compliance with this specification and shall be labeled in compliance with Section 1517 of the *Florida Building Code, Building*. Product Approval documents shall be provided to the purchaser or end user upon request.

8.2 Shipping containers shall be marked with the name of the material, stock number, lot number, year of issue and quantity therein and the name of the manufacturer or supplier.

9. Rejection and Reinspection:

9.1 The Authority Having Jurisdiction may periodically purchase commercial quantities of the approved product for testing at Approved Testing Agencies to confirm compliance with the provisions of this Protocol. Failure to meet the minimum requirements set forth in Sections 5 and 6 shall constitute grounds for rejection of the lots and suspension of the Product Approval. In cases of rejection the Chief Code Compliance Officer shall request removal of the rejected lot number(s) from commercial sale.

9.2 The Chief Code Compliance Officer may, after rejection of one or more lots, require third party quality control inspection as a provision to lifting of Approval suspension.

9.3 Shipping containers shall be marked with the name of the material, the stock number, lot number, quantity therein, and the name of the manufacture or supplier.

TESTING APPLICATION STANDARD (TAS) 140-95

STANDARD REQUIREMENTS FOR NONFIBERED ROOF AND FOUNDATION COATINGS

1. Scope:

1.1 This Protocol covers nonfibered asphalt roof and foundation coatings suitable for brush or spray application.

1.2 The Protocol is provided as a guide for the selection and proper use of Non-Fibered Roof and Foundation coatings.

1.3 This standard specifically addresses laboratory testing of these coatings and does not provide guidance for actual field application.

1.4 All testing shall be conducted by an approved testing agency and all test reports shall be signed by an authorized signer of the testing agency and/or professional engineer.

2. Referenced Documents:

2.1 *ASTM Standards*

D 16	Terminology Relating to Paint, Varnish, Lacquer and Related Products.
D 312	Standard Specification for Asphalt Used in Roofing
D 449	Standard Specification for Asphalt Used in Dampproofing and Waterproofing.
D 946	Penetration Graded Asphalt Cement for Use in Pavement Construction.
D 1079	Standard Definitions of Terms Relating to Roofing, Waterproofing, and Bituminous Materials.
D 4479	Standard Specification for Asphalt Roof Coatings - Asbestos Free.
E 380	Excerpts from Standard Practice for Use of the International System of Units (SI) (The Modernized Metric System.)

2.2 *Florida Building Code, Building*

2.3 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions - For definitions of terms used in this Protocol, refer to ASTM D 16; and/or ASTM D 1079; and/or Chapter 2 of the *Florida Building Code, Building* and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Limitations and Precautions:

4.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this Protocol to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Materials and Manufacture:

5.1 The coating shall consist of an asphalt base and volatile petroleum solvent mixed to a smooth consistency.

5.2 The coating shall be formulated as one component which is suitable for application by brush or spray equipment without heating or thinning.

5.3 The coating shall be suitable for application and will adhere to clean, dry, properly prepared roofing substrate.

5.4 The coating is not intended for use where ponding water conditions exist.

5.5 Asphalts that conform to the requirements of Specification D 312, Type I; Specification D 449, Types I or II; or Specification D 946 shall be used.

5.6 *Composition* - The non-fiber roof coating product shall conform to composition requirements as follows:

Component Property	**MIN.**	**MAX.**
Non-Volatile, (%)	60	—
Moisture, (%)	—	1
Asphalt, (%)	60	—

6. Performance Requirements:

6.1 *Physical Properties* - The non-fibered roof coating product shall conform to physical property requirements as follows:

Physical Property	**Test Standard**	**Requirement**
Consistency *(use 100 g load)*	D 4479 Section 8.4	15-75 Stormer seconds
Moisture Content, (%)	D 95	max. 1%
Non-Volatile, (%)	D 4479 Section 8.2	min. 60%
Matter Soluble in Trichloroethylene, (%)	D 2042	min. 99%

7. Packaged Material:

7.1 Packaged material shall be certified by the manufacturer to be in compliance with this specification and shall be labeled in compliance with Section 1517 of the *Florida Building Code, Building*. Product Approval documents shall be provided to the purchaser or end user upon request.

7.2 Shipping containers shall be marked with the name of the material, stock number, lot number, year of issue and quantity therein and the name of the manufacturer or supplier.

8. Rejection and Reinspection:

8.1 The Authority Having Jurisdiction may periodically purchase commercial quantities of the approved product for testing at Approved Testing Agencies to confirm compliance with the provisions of this Protocol. Failure to meet the minimum requirements set forth in Sections 5 and 6 shall constitute grounds for rejection of the lots and suspension of the Product Approval. In cases of rejection the Chief Code Compliance Officer shall request removal of the rejected lot number(s) from commercial sale.

8.2 The Chief Code Compliance Officer may, after rejection of one or more lots, require third party quality control inspection as a provision to lifting of Approval suspension.

8.3 Shipping containers shall be marked with the name of the material, the stock number, lot number, quantity therein, and the name of the manufacturer or supplier.

TESTING APPLICATION STANDARD (TAS) 141-95

STANDARD REQUIREMENTS FOR COAL TAR (CUTBACK) ROOF COATING, BRUSHING CONSISTENCY

1. Scope:

1.1 This Protocol covers a coal tar base roof coating containing mineral filler or stabilizer and volatile solvent, suitable for brush application.

1.2 The property requirements used to characterize this product are minimum performance values intended to ensure that the product is fit for its intended use.

1.3 This Protocol specifically addresses laboratory testing of these coatings and does not provide guidance for actual field application.

1.4 All testing shall be conducted by an approved testing agency and all test reports shall be signed by an authorized signer of the testing agency and/or professional engineer.

2. Referenced Documents:

2.1 *ASTM Standards*

D 16	Terminology Relating to Paint, Varnish, Lacquer and Related Products
D 93	Flash Point by Fensky-Martens Closed Tester
D 95	Test Methods for Water in Petroleum Products and Bituminous Materials by Distillation
D 140	Standard Practice for Sampling Bituminous Materials
D 482	Ash from Petroleum Products
D 562	Standard Test Method for Consistency of Paints Using the Stormer Viscometer
D 1079	Definition of Terms Relating to Roofing, Waterproofing, and Bituminous Materials
D 2196	Standard Test Methods for Rheological Properties of Non-Newtonian Material by Rotational (Brookfield) Viscometer
D 4990	Specification for Coal Tar Glass Felts Used in Roofing and Waterproofing
E 380	Use of the International System of Units (SI) (The Modernized Metric System)

2.2 *The Florida Building Code, Building*

2.3 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions - For definitions of terms used in this Protocol, refer to ASTM D 16 and/or ASTM D 1079 and/or Chapter 2 of the *Florida Building Code, Building* and/or the RCI Glossary of Terms. The definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Limitations and Precautions:

4.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this Protocol to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Materials and Manufacture:

5.1 Coal tar coating shall consist of refined coke oven tar, plasticizing oils, and aromatic and/or aliphatic tar solvents blended with mineral and/or other stabilizers excluding asbestos, to yield a heavy brushing consistency ready for use from the storage container.

5.2 *Composition* - The coal tar base roof coating product shall conform to composition requirements as follows:

Component Property	Reference Section	Requirements
Non-Volatile Material	See Section 7.1	min. 60%
Ash Content	See Section 7.2	min. 5%
Water Content	See Section 7.3	max. 3%

6. Performance Requirements:

6.1 Condition in Container

6.1.1 The material shall be a smooth, homogenous mixture, after stirring, and shall be ready for use without heating or thinning. Settling in the container shall not occur to the extent that a hard cake which cannot be redispersed by hand mixing forms at the bottom of the container at 60°F (15.5°C) or above.

6.2 *Physical Properties* - The coal tar base roof coating product shall conform to physical property requirements as follows.

Physical Property	Referenced Standard	Requirement
Viscosity	See Section 7.5	min. 6 max. 16
Flashpoint	See Section 7.6	min. 170°F (74.6°C)
Accelerated Weathering	See Section 7.8.1	no more than hairline surface cracks and no loss of adhesion
Low Temperature Flexibility	See Section 7.8.2	no more than hairline surface cracks and no loss of adhesion

6.3 *Coating* - Coating shall be of a heavy brushing consistency to insure a film thickness of approximately $^1/_{32}$ in. (0.79 mm) at material temperature up to 90°F (32.2°C), and yet not as stiff at 60°F (15.5°C) to prevent easy application with a suitable brush at the rate of approximately 1 gallon per 50 square feet over bituminous roofing, when tested in accordance with Section 7.4, herein.

6.4 *Penetration and Saturation* - The coating shall penetrate and stain at least the top 12 blotter sheets in the stack, and at least the top 9 blotter sheets shall show saturation a minimum of 95% of the total surface area of each sheet. The twelfth blotter sheet from the top shall show a stain area of at least 2 inches in diameter, when tested in accordance with Section 7.7, herein.

6.4 *Shelf Storage Life* - When stored as specified in Section 7.9 of this Protocol, the coating shall conform to Sections 5.1, and 6.1.1. However, the viscosity may vary ± 10% from the values specified above.

7. Test Methods:

7.1 *Nonvolatile Matter* - Weigh approximately 10 grams (g) of the sample into a tarred, flat bottom metal dish about 3.15 inches (8 cm) in diameter, or into a quart friction top can plug. Heat the dish with its contents in a forced draft circulating oven at 325° ± 2°F (162.8° ± 1.1°C) for five hours. Cool and weigh. From the weight of the residue in the dish and from the weight of the original sample taken, compute the percentage of nonvolatile matter.

7.2 *Ash Content* - Scrape from the metal dish in Section 7.1 herein a large portion of the residue nonvolatile matter into a previously fired and tarred crucible. Weigh the sample. Slowly burn off the combustible matter and ignite to constant weight. Cool and weigh. Calculate the percentage of ash based on the original sample as in Specification D 482.

7.3 *Water Content* - Determine water content in accordance with Specification D 93.

7.4 *Coating* - Prepare an area 50 in. x 36 in. (1270 mm x 914.4 mm) of roofing felt conforming to Specification D 4990, firmly fastened and in a horizontal position. Apply to this specimen one quart of the coating material at a temperature of 77°F ± 2°F (25°C ± 1.1°C). Spread the coating over the surface, using a suitable brush which has been saturated with the coating material. *(See Section 6.3, herein.)*

7.5 *Viscosity* - Determine the viscosity of the coating on a model HBT 200 or equivalent Brookfield Viscometer using a #3 Spindle at 2.5 RPM at 77°F ± 2°F (25°C ± 1.1°C). Read values on the 0-100 scale. The sample tested should be contained in a one pint can.

7.6 *Flashpoint* - Determine flashpoint in accordance with Specification D 93 using the procedure for determination of flashpoint of suspension of solids.

7.7 *Penetration and Saturation* - Place a metal ring $2^5/_8$ in. (66 mm) in diameter and $^1/_2$ in. (13 mm) high on top of a stack of 20 sheets of 4 in. x 4 in. white blotter paper. (Blotter specifications: white, uncoated 200M/1000 sheets). Stir the coating until homogeneous, and fill the ring level full with the coating. Place the ring-paper coating assembly in a forced draft circulating oven for 24 hours at 158°F ± 2°F (70°C ± 1.1°C). Remove the assembly from the oven, and cool to room temperature of 77°F ± 2°F (25°C ± 1.1°C). Carefully, remove the ring from the assembly by running a thin blade knife around the inside of the ring separating the coating from the ring. Examine the blotter paper stack for depth of penetration of coating and saturation of sheets *(See Section 6.4, herein).*

7.8 Behavior at Warm and Cold Temperature

7.8.1 *Accelerated Aging* - Prepare a stack of 20 pieces of 40 Whatman filter paper, 0.28 in. (7.1 mm) in diameter. Place the stack of filter papers on one sheet of 4 in. x 4 in. blotter paper. Place a ring as in Section 7.7 on top of the stack, and fill level full with a sample of thoroughly mixed coating. Age the test assembly in a forced-draft circulation oven at 158°F ± 2°F (70°C ± 1.1°C) for seven days. Remove the test assembly from the oven and cool to room temperature of 77°F ± 2°F (25°C ± 1.1°C). As in Section 7.7 remove the ring from the assembly. Bend the specimen over $^1/_4$ in. (6 mm) mandrel in not more than two seconds. Examine for cracking, loss of adhesion, embrittlement.

7.8.2 *Low Temperature Flexibility* - After recording data for Section 7.7, place the paper coating assembly into a cold box at 32°F ± 2°F (0°C ± 1.1°C) for six hours. Remove the assembly from the cold box and immediately bend over a 1 in. (25 mm) mandrel within two seconds. Not more than five seconds should elapse between removal of specimen from cold box and bending of specimen.

7.9 *Shelf Storage Life* - One container of coating shall be stored for 18 months from the date of manufacture at 77°F ± 2°F (25°C ± 1.1°C) and a relative humidity of 50% ± 5% and then shall be tested to determine compliance with the requirements of Section 6.4, herein.

8. Sampling:

8.1 Sample the material from the original container immediately after stirring to a uniform consistency, in accordance with Practice D 140.

8.2 Restir samples to obtain uniformity immediately before withdrawing portions for individual tests.

9. Packaged Material:

9.1 Packaged material shall be certified by the manufacturer to be in compliance with this specification and shall be labeled in compliance with Section 1517 of the *Florida Building Code, Building*. Product Approval documents shall be provided to the purchaser or end user upon request.

9.2 Shipping containers shall be marked with the name of the material, stock number, lot number, year of issue and quantity therein and the name of the manufacturer or supplier.

10. Rejection and Reinspection:

10.1 The Authority Having Jurisdiction may periodically purchase commercial quantities of the approved product for testing at Approved Testing Agencies to confirm compliance with the provisions of this Protocol. Failure to meet the minimum requirements set forth in Sections 5 and 6 shall constitute grounds for rejection of the lots and suspension of the Product Approval. In cases of rejection the Chief Code Compliance Officer shall request removal of the rejected lot number(s) from commercial sale.

10.2 The Chief Code Compliance Officer may, after rejection of one or more lots, require third party quality control inspection as a provision to lifting of Approval suspension.

10.3 Shipping containers shall be marked with the name of the material, the stock number, lot number, quantity therein, and the name of the manufacturer or supplier.

TESTING APPLICATION STANDARD (TAS) 142-95

STANDARD REQUIREMENTS FOR COAL TAR ROOF CEMENT, ASBESTOS FREE

1. Scope:

1.1 This Protocol covers coal tar roof cement suitable for trowel application in coal tar roofing and flashing systems.

1.2 All testing shall be conducted by an approved testing agency and all test reports shall be signed by an authorized signer of the testing agency and/or Professional Engineer.

2. Referenced Documents:

2.1 *ASTM Standards*

D 4	Test Method for Bitumen Content.
D 16	Terminology Relating to Paint, Varnish, Lacquer and Related Products
D 95	Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D 140	Practice for Sampling Bituminous Materials
D 1079	Definition of Terms Relating to Roofing, Waterproofing, and Bituminous Materials
D 3143	Test Method for Flash Point of Cutback Asphalt with Tar Open-Cup Apparatus
D 3409	Test Method for Adhesion of Asphalt-Roof Cement to Damp, Wet, or Underwater Surfaces
D 4586	Standard Specification for Asphalt Roof Cement, Asbestos Free
E 380	Use of the International System of Units (SI) (The Modernized Metric System)

2.2 *The Florida Building Code, Building*

2.3 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions - For definitions of terms used in this Protocol, refer to ASTM D 16; and/or ASTM D 1079; and/or Chapter 2 of the *Florida Building Code, Building* and/or the RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Limitations and Precautions:

4.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this Protocol to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Materials and Manufacture:

5.1 Coal tar roof cement shall consist of a processed coal tar base, volatile solvents, and mineral stabilizer, excluding asbestos, mixed to a smooth uniform consistency suitable for trowel applications.

5.2 *Composition* - The coal tar roof cement product shall conform to composition requirements as follows:

Component Property	Test Standard	Requirements
Water Content	D 95	max. 2% volume
Nonvolatile Matter *(Heat Dish and Contents in Oven at 221 to 230°F)*	D 2822	min. 65% mass
Insoluble Matter	D 4 Procedure #2	15-40% mass

6. Performance Requirements:

6.1 Physical Properties - The coal tar roof cement product shall conform to physical property requirements as follows:

Physical Property	Test Standard	Requirement
Behavior at 140°F (60°C)	D 4586 Section 8.4	no evidence of blistering and sag or sides shall be no greater that $^{1}/_{4}$ in. (6 mm)
Flashpoint	D 3143	min. 100°F (38°C)
Adhesion to Wet Surfaces	D 3409	min. avg. 75%

6.2 *Uniformity* - A thoroughly stirred sample shall show no separation of solvent or settling that cannot be overcome by moderate stirring after standing for 72 hours at room temperature (77°F ± 3.6°F, 25°C ± 1.1°C) in a closed container.

6.3 *Workability* - The cement shall be of such a consistency that it will spread readily and permit troweling smooth coatings $^{1}/_{16}$ in. to $^{1}/_{8}$ in. (1.6 to 3.2 mm) thick on vertical surfaces.

7. Sampling:

7.1 Sample the material from the original container immediately after stirring to a uniform consistency, in accordance with Practice D 140.

7.2 Restir samples to obtain uniformity immediately before withdrawing portions for individual tests.

8. Package and Package Marking:

8.1 Packaged material shall be certified by the manufacturer to be in compliance with this specification and shall be labeled in compliance with Section 1517 of the *Florida Building Code, Building*. Product Approval documents shall be provided to the purchaser or end user upon request.

8.2 Shipping containers shall be marked with the name of the material, stock number, lot number, year of issue and quantity therein and the name of the manufacturer or supplier.

9. Rejection and Reinspection:

9.1 The Authority Having Jurisdiction may periodically purchase commercial quantities of the approved product for testing at Approved Testing Agencies to confirm compliance with the provisions of this Protocol. Failure to meet the minimum requirements set forth in Sections 5 and 6 shall constitute grounds for rejection of the lots and suspension of the Product Approval. In cases of rejection the Chief Code Compliance Officer shall request removal of the rejected lot number(s) from commercial sale.

9.2 The Chief Code Compliance Officer may, after rejection of one or more lots, require third party quality control inspection as a provision to lifting of Approval suspension.

9.3 Shipping containers shall be marked with the name of the material, the stock number, lot number, quantity therein, and the name of the manufacturer or supplier.

TESTING APPLICATION STANDARD (TAS) 143-95

STANDARD REQUIREMENTS FOR WHITE ELASTOMERIC ROOF COATINGS USED FOR COATING BUILT UP ROOFS AND METAL ROOFING SYSTEMS

1. Scope:

1.1 This Protocol covers white elastomeric roof coatings, suitable for roller, brush or spray application as a reflective and protective coating for built up and metal roof surfaces that are sloped for positive drainage.

1.2 The property requirements used to characterize this product are minimum performance values intended to ensure that the product is fit for its intended use.

1.3 This Protocol specifically addresses laboratory testing of these coatings and does not provide guidance for actual field application.

1.4 All testing shall be conducted by an approved testing agency and all test reports shall be signed by an authorized signer of the testing agency and/or professional engineer.

2. Referenced Documents:

2.1 *ASTM Standards*

C 661	Standard Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer
C 794	Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
D 412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers - Tension
D 471	Test Method for Rubber-Effects of Liquids
D 562	Standard Test Method for Consistency of Paints Using the Stormer Viscometer
D 1079	Standard Definitions of Terms Relating to Roofing, Waterproofing, and Bituminous Materials
D 2196	Standard Test Methods for Rheological Properties of Non-Newtonian Material by Rotational (Brookfield) Viscometer
D 2697	Test Methods for Volume Nonvolatile Matter in Clear or Pigmented Coatings
D 2824	Standard Specification for Aluminum-Pigmented Asphalt Roof Coatings
E 96	Standard Test Methods for Water Vapor Transmission of Materials
E 380	Excerpts from Standard Practice for Use of the International System of Units (SI) (the Modernized Metric System)
G 21	Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
G 26	Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials

2.2 *The Florida Building Code, Building*

2.3 *Roof Consultants Institute*
Glossary of Terms

3. Terminology & Units:

3.1 Definitions - For definitions of terms used in this Protocol, refer to ASTM D 16; and/or ASTM D 1079; and/or Chapter 2 of the *Florida Building Code, Building* and/or The RCI Glossary of Terms. Definitions from the *Florida Building Code, Building* shall take precedence.

3.2 Units - For conversion of U.S. customary units to SI units, refer to ASTM E 380.

4. Limitations and Precautions:

4.1 This Protocol may involve hazardous materials, operations and equipment. This Protocol does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this Protocol to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

5. Materials and Manufacture:

5.1 *Composition* - The product, as manufactured, shall be a one component, water based, white elastomeric coating, suitable for application by roller, brush or spray equipment without heating or thinning.

5.2 The coating shall be suitable for the application intended and bond well to clean, dry, properly prepared, built-up roofing materials, metal, poured-in-place concrete, asphalt shingles, modified bitumen, masonry, clay tile and wood surfaces, using a primer when necessary.

5.3 The coating shall be suitable for application where sunlight and surface and ambient temperatures of 50° ± 2°F (10° ± 1.1°C) or above, are maintained long enough for the coating to dry.

6. Performance Requirements:

6.1 Although the product is supplied as a liquid, its performance is based on the functional properties of the cured material in membrane form. The coating is formed into a fully adhered sheet adhered to the roofing substrate.

6.2 Physical Properties (Liquid Form) - The white elastomeric roof coating product, in its liquid form, shall conform to physical property requirements as follows.

Physical Property	Test Standard	Requirement
Viscosity	D 562	85-141 KU
Viscosity	D 2196 See Section 7.2	12,000-85,000
Volume, Solids %	D 2697	>45%

6.3 *Physical Properties (Membrane Form)* - The white elastomeric roof coating product, in its membrane form, shall conform to physical property requirements as follows.

7. Test Methods:

7.1 *Preparation of Coating Specimens* - unless otherwise noted, test specimens shall be prepared as follows.

7.1.1 Test specimens shall be prepared by applying two coats to release paper to give a total dry film thickness of 20 mils.

7.1.2 The test specimen shall be allowed to cure at 77°F (25°C) and 50% relative humidity for 14 days.

7.1.3 The test specimen shall be flipped over after 7 days.

7.2 *Viscosity* - Test Method D 2196

7.2.1 Brookfield viscometer, #6 20 RPM RTV Viscometer

7.3 *Elongation* - Test Method D 412 (Instron or equivalent), except as noted below.

7.3.1 Prepare test specimens as noted in Section 7.1, herein.

7.3.2 Cut specimen in a dumbbell shape measuring 3 in. long by $^3/_4$ in. wide and having a neck width of $^1/_4$ in.

7.3.3 Test type of functional equivalent:

Cross head speed	0.2 in. per min.
Chart speed	0.2 in. per min.
Gauge length	0.5 in. opening
Calibration	according to compound
Integrator	automatic

Physical Property	Reference Section	Requirements
Percent Elongation *(After 50 Hours Weather-Ometer)*	See Section 7.3	min. 200% @ 107°F (42°C) min. 100% @ 30°F (–1°C)
Percent Elongation *(After 3000 Hours Weather-Ometer)*	See Section 7.3	min. 160% @ 107°F (42°C) min. 80% @ 30°F (–1°C)
Recovery *(After 50 Hours Weather-Ometer)*	See Section 7.4	min. 50% @ 107°F (42°C) min. 50% @ 30°F (–1°C)
Recovery *(After 3000 Hours Weather-Ometer)*	See Section 7.4	min. 40% @ 107°F (42°C) min. 40% @ 30°F (–1°C)
Tensile Strength *(After 14 Days Aging)*	See Section 7.6	min. 180 @ 107°F (42°C) min. 180 @ 30°F (–1°C)
Hardness	See Section 7.7	min. 55 @ 77°F (25°C)
Water Vapor Transmission	See Section 7.9	max. 20 perms
Water Swelling	See Section 7.10	max. 20%
Accelerated Weathering	See Section 7.11	No cracking or checking
Adhesion	See Section 7.12	min. 4lb/in-width (dry) min. 2 lb/in-width (wet)
Low Temperature Flexibility	See Section 7.5	Pass 30°F (-1°C) ($^1/_2$ in. Mandrel)
Fungi Resistance	See Section 7.13	28 days, 0-1 rating, max. growth 10%
Reflectance	See Section 7.8	>85%
Reflectance *(After Dirt Pickup)*	See Section 7.8	>76%

7.3.4 Calculate percent elongation (E) in compliance with the following equation:

$$E = \left(\frac{L - L_0}{L_0}\right) \times 100$$

where,

E = percent elongation (%);

L = sample length at break (in.); and,

L_o = gage length (in.)

7.3.5 For low temperature testing, the specimen shall be kept in a cold box at the appropriate low temperature for not less than 1 hour, then tested immediately.

7.3.6 A Xenon-Arc Weather-Ometer shall be used. See Section 7.12, herein.

7.4 *Recovery* - Test Method D 412, except as noted below.

7.4.1 Prepare test specimens as noted in Section 7.1, herein.

7.4.2 Cut specimen in a dumbbell shape measuring 3 in. long by $^3/_4$ in. wide and having a neck width of $^1/_4$ in.

7.4.3 25% extension, immediate recovery.

7.4.4 For low temperature testing, the specimen is to be kept in a cold box at the appropriate low temperature for at least 1 hour, then tested immediately.

7.4.5 A Xenon-Arc Weather-Ometer shall be used for exposure prior to elongation testing. Refer to Section 7.11, herein.

7.5 *Low Temperature Flexibility* - Test Method C 734, except as noted below.

7.5.1 Prepare test specimen as in Section 7.1, herein.

7.5.2 For low temperature testing, the specimen shall be kept in a cold box at the appropriate low temperature for not less than 1 hour, then tested immediately.

7.5.3 Bend specimen 180° over a $^{1}/_{2}$ in. diameter mandrel.

7.5.5 A Xenon-Arc Weather-Ometer shall be used. See Section 7.11, herein.

7.6 *Tensile Strength* - Test Method D 412, except as noted below.

7.6.1 Prepare test specimen as in Section 7.1, herein.

7.6.2 Cut specimen in a dumbbell shape measuring 3 in. long by $^{3}/_{4}$ in. wide and having a neck width of $^{1}/_{4}$ in.

7.6.3 Test type of functional equivalent:

Cross head speed	0.2 in. per min.
Chart speed	0.2 in. per min.
Gauge length	0.5 in. opening
Calibration	according to compound
Integrator	automatic

7.6.4 Tensile strength in pounds/inch^2 $= \frac{f}{tw}$

where:

f = the force at break in pounds;

w = the sample width in inches (0.25 in.); and

t = the sample thickness in inches.

7.6.5 For low temperature testing, the specimen shall be kept in a cold box at the appropriate low temperature for not less than 1 hour, then tested immediately.

7.7 *Shore A Hardness* - Test Method C 661, except as noted below.

7.7.1 Prepare test specimen as in Section 7.1, herein.

7.7.2 Cut specimen in a dumbbell shape measuring 3 in. long by $^{3}/_{4}$ in. wide and having a neck width of $^{1}/_{4}$ in.

7.7.3 Test with a Shore 'A' Durometer, taking readings by the instantaneous method using 1-kilogram pressure.

7.7.4 The final result shall be the average of six readings.

7.8 *Reflectance* - Test Method D 2824, Section 8.6, except as noted below.

7.8.1 Coating test specimens are cast at 40 wet mils on 6 in. x 3 in. aluminum panels (suitable to fit QUV).

7.8.2 Test specimens shall be dried at ambient conditions 24 hours prior to testing.

7.8.3 Test specimens shall be placed in the QUV Cabinet for 4 hours UV radiation. The CPR QUV shall be equipped with UV-A bulbs (less severe than UV-B bulbs) and shall operate with no humidity cycle.

7.8.4 Allow test specimens to equilibrate 2 hours.

7.8.5 Iron oxide slurry shall be brushed on one half of each panel, then dried one hour at room temperature.

Note: Brown iron oxide slurry is 56% iron oxide mechanically mixed until smooth in DI water.

7.8.6 Test specimens shall be washed under running luke warm tap water. Use moderate pressure with a cheese cloth pad to wipe off all excess iron oxide. Use a fresh cheese cloth pad for each sample.

7.8.7 Allow panels to dry two hours, then measure % reflectance on tested and non-tested portions using Gardner Colorgard II Reflectometer.

Note: Colorgard II Reflectometer 45° head Gardner Neotec Division, Pacific Scientific.

7.8.8 Report % reflectance; retained.

7.9 *Water Vapor Transmission* - Test Method E 96-80 BW (3.2, 12.4) "The Water Method," except as noted below.

7.9.1 To prepare test specimens, a 20 mil wet drawdown of coating is allowed to cure for 4 hours. A Gardner knife is subsequently adjusted to 30 mils and a second drawdown is placed on top of the partially cured 20 mil coating. The test specimens are allowed to cure at 77°F (25°C) and 50% relative humidity for seven days and then flipped over and cured an additional seven days (total cure time 14 days).

7.9.2 Fill an ASTM perm cup with 20 mil of distilled water and invert it so that the water is in physical contact with the coating film.

7.9.3 Place the perm cup over an open grid rack and maintain at a constant 50% relative humidity.

7.9.4 Plot the weight loss against time until a nominal steady state exists. The slope of the straight line is the rate of water vapor transmission.

7.9.5 Calculate the water vapor transmission (WVT) and permeance (P) in metric units using the following equations.

Water Vapor Transmission:

$$WVT = \frac{G}{T \times A}$$

where,

WVT = rate of water vapor transmission, g/h-m^2;

G = weight change, g (from the straight line);

T = time corresponding to weight change, hours; and,

A = test area (per cup mouth area), m^2.

Notes:

1. For cup radius of 0.028 m, A = 0.00246 m^2

Permeance:

$$P = \frac{WVT}{S \times (R_1 - R_2)}$$

where,

P = permeance (g/Pa-s-m^2);

WVT = rate of water vapor transmission, g/h-m^2;

S = saturation vapor pressure at test temperature, mm Hg

R_1 = relative humidity at source expressed as fraction; and,

R_2 = relative humidity at the vapor sink expressed as fraction

Notes:

1. 1 mm Hg = 133 Pa
2. R1 = 1.00 in the perm cup for the water method.
3. For constant temperature room (CTR), relative humidity expressed as decimal fraction (0.50).
4. Permeance values expressed as ng/Pa-s-m^2 are equivalent to 1 perm.

7.10 *Swelling* - Test Method D 471, Section 9, except as noted below.

7.10.1 Prepare test specimen as in Section 7.9.1, herein.

7.10.2 A 20 mm disc is cut out of the cured test specimen using a No. 15 cork borer.

7.10.3 Weigh each disk.

7.10.4 Immerse the disk specimen in tap water. Periodically remove the disk from the water (i.e., 2, 4, 6, 8, 10, etc.hours), dry the surface with filter paper, and reweigh.

7.10.5 The swell ratio (weight of coating plus water divided by initial coating weight) is calculated and plotted as a function of time.

This procedure is continued until an equilibrium swell ratio is obtained.

7.11 *Accelerated Weathering* - Test Method G 26, except as noted below.

7.11.1 To prepare test specimens, the coating is cast on a $2^5/_8$ in. x $5\ ^3/_4$ in. plate of $^1/_{32}$ in. thick aluminum, at 20 mils dry film thickness, and allowed to cure at 77°F (25°C) and 50% relative humidity for 3 days. Two such specimens are prepared.

7.11.2 After curing, one test specimen is placed in a Xenon-Arc Weatherometer for 3000 hours of accelerated weathering. The second test specimen is air cured at 77°F (25°C) and 50% relative humidity for the duration of this exposure.

7.11.3 When 3000 hours have elapsed, the original specimen is removed from the weatherometer and allowed to cool at 77°F (25°C) and 50% relative humidity for 2 hours.

7.11.4 The two specimens are then compared for appearance differences (color, cracking, adhesion loss, etc.)

7.12 *Adhesion* - Test Method C 794, except as noted below.

7.12.1 Test specimens are prepared by applying two coats to clean, fine spangle galvanized metal Q-Panels, to give a total dry film thickness of 20 mils. The coating is allowed to cure at 77°F (25°C) and 50% relative humidity for 14 days.

7.12.2 Crosshead speed shall be 2 inches per minute.

7.13 *Fungi Resistance* - Test Method G 21.

8. Packaged Material

8.1 Packaged material shall be certified by the manufacturer to be in compliance with this specification and shall be labeled in compliance with Section 1517 of the *Florida Building Code, Building*. Product Approval documents shall be provided to the purchaser or end user upon request.

8.2 Shipping containers shall be marked with the name of the material, stock number, lot number, year of issue and quantity therein and the name of the manufacturer or supplier.

9. Rejection and Reinspection

9.1 The Authority Having Jurisdiction may periodically purchase commercial quantities of the approved product for testing at Approved Testing Agencies to confirm compliance with the provisions of this Protocol. Failure to meet the minimum requirements set forth in Sections 5 and 6 shall constitute grounds for rejection of the lots and suspension of the Product Approval. In cases of rejection the Chief Code Compliance Officer shall request removal of the rejected lot number(s) from commercial sale.

9.2 The Chief Code Compliance Officer may, after rejection of one or more lots, require third party quality control inspection as a provision to lifting of Approval suspension.

9.3 Shipping containers shall be marked with the name of the material, the stock number, lot number, quantity therein, and the name of the manufacturer or supplier.

TESTING APPLICATION STANDARD (TAS) 201-94

IMPACT TEST PROCEDURES

1. Scope:

1.1 This protocol covers procedures for conducting the impact test of materials as required by Section 1626 of the *Florida Building Code, Building*.

2. Referenced Documents:

2.1 *The Florida Building Code, Building*

3. Terminology:

3.1 Definitions - For definitions of terms used in this protocol, refer to Sections 1625, 1626 and/or Chapter 2 of the *Florida Building Code, Building*.

3.2 Description of Terms Specific to This Protocol.

3.2.1 Specimen - The entire assembled unit submitted for test, including but not limited to anchorage devices and structure to which product is to be mounted.

3.2.2 Test Chamber - An airtight enclosure of sufficient depth to allow unobstructed deflection of the specimen during pressure cycling, including ports for air supply and removal, and equipped with instruments to measure test pressure differentials.

3.2.3 Maximum Deflection - The maximum displacement of the specimen measured to the nearest $^1/_8$ of an inch attained from the original position while the maximum test load is being applied.

3.2.4 Permanent Deformation - The permanent displacement of the specimen measured to the nearest $^1/_8$ of an inch from the original position to final position that remains after maximum test load has been removed.

3.2.5 Test Load - As determined by Sections 1606, 1625, and 1626 of the *Florida Building Code, Building*.

3.2.6 Specimen Failure - A change in condition of the specimen indicative of deterioration under repeated load or incipient failure, such as cracking, fastener loosening, local yielding, or loss of adhesive bond.

4. Significance and Use:

4.1 The test procedures outlined in this protocol provide a means of determining whether a particular product used as wall cladding, exterior windows, glazing, exterior doors, skylights, glass block, shutters and any other similar device used as external protection to maintain the envelope of the building, provides sufficient resistance to windborne debris, as stated in Section 1626 of the *Florida Building Code, Building*.

5. Test Specimen:

5.1 *Test specimen* - All parts of the test specimen shall be full size, using the same materials, details, methods of construction and methods of attachment as proposed for actual use. The specimen shall consist of the entire assembled unit attached to a given type of structural framing of the building, and shall contain all devices used to resist wind forces and windborne debris. When testing glazed products, the material used to make such glazed product windborne debris resistant (i.e., fillers, film and similar), shall be an integral part, factory applied, of such glazed product.

In the case of windows, doors, and sliding glass doors, a pressure treated nominal 2 x 4 wood buck #3 Southern Pine shall be used for attachment of the specimen to the test frame/stand/chamber. Such wood buck will become part of the approval.

In the case of storm panels, they must be tested in worst case scenarios where attachments are directly to CBS block. Figure 1, on the following page, shows the basic three (3) configurations that shall be required; one per each of the three (3) required specimens. Each storm panel specimen shall consist of minimum three (3) panels.

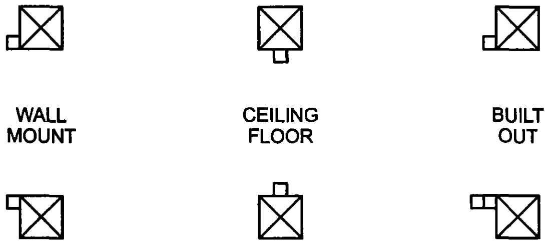


FIGURE 1
THREE (3) BASIC STORM PANEL ATTACHMENTS FOR TESTING

5.1.1 Locking mechanisms shall be permanently mounted on the specimen. Such locking mechanism shall require no tools to be latched in the locked position. Devices such as pins shall be permanently secured to the specimen through the use of chains or wires which must be of corrosion resistant material. This section does not apply to specimens referenced in Section 2413 of the *Florida Building Code, Building*.

5.1.2 Products that are not categorized as means of egress/escape and are provided with more than one single action locking mechanism, shall be provided with permanently posted instructions on latching for high wind pressures.

5.1.3 Specimen and fasteners, when used, shall not become disengaged during test procedure.

6. Apparatus:

6.1 The description of the apparatus is general in nature. Any equipment, properly certified, calibrated, and approved by the Authority Having Jurisdiction capable of performing this test within the allowable tolerance is permitted.

6.2 Major Components

6.2.1 Cyclic Wind - Pressure Loading As described in protocol TAS 203-94. (Number of cycles and amount of pressure are indicated in Section 1625.4, Table 1625 and Table 1626 of the *Florida Building Code, Building*. Design wind pressure is to be determined by using Section 1619 of the *Florida Building Code, Building*.)

6.2.1.1 *Test Chamber* - The test chamber, to which the specimen is mounted, shall be provided with pressure taps to measure the pressure difference across the test specimen and shall be so located that the reading is unaffected by the velocity of air supplied to or from the chamber. The specimen mounting frame must not deflect under test load in such a manner that the performance of the specimen will be affected.

6.2.1.2 *Air System* - A controllable blower, a compressed-air supply, an exhaust system, or reversible controllable blower designed to provide the required maximum air pressure difference across the specimen. The system shall provide an essentially constant air-pressure difference for the required test period.

6.2.1.3 *Test temperature* - The test shall be conducted at a test temperature range of 59 to 95° F (15 to 35° C).

6.3 *Missile Impact*

6.3.1 Timing System - The timing system, which is comprised of two, through-beam photoelectric sensors spaced at a known distance apart and used to start and stop an electronic clock, shall be capable to measure speeds accurate to ±2%. The speed of the missile shall be measured anywhere between the point where 90% of the missile is outside of the cannon, to the point where the missile is 1 ft. away from the test specimen. The missile speed shall not be measured while the missile is accelerating. The through-beam photoelectric sensors shall be of the same model.

The electronic clock shall be activated when the reference point of the missile passes through the timing system. The electronic clock shall have an operating frequency of no less than 10 kHz with a response time not to exceed 0.15 milliseconds. The speed of the missile shall be determined by dividing the distance between the two through-beam photoelectric sensors by the total time interval counted by the electronic clock.

6.3.1.1 *Calibration of Timing Equipment* - The timing system shall be calibrated and certified by an independent qualified agency approved by the Building Code Compliance Officer, at six-month intervals using one of the following methods:

1. Photographically, using a stroboscope,
2. Photographically, using a high speed camera with a frame rate exceeding 500 frames per second,
3. Photographically, using a high speed video camera with a frame rate exceeding 500 frames per second, or
4. Any other certified timing system calibration device used by an independent certified agency approved by this office.

The calibration report shall include: the date of the calibration, the name of the agency conducting the calibration, the distance between the through-beam photoelectric sensors (if used), the speed of the missile as measured by the timing system, the speed of the missile as determined from the calibration system, and the percentage difference in speeds. The system shall be determined to be accurate if the speed of the missile measured by the timing system and the speed measured by the calibration system agree within 2%.

6.3.2.1 *LARGE MISSILE* - The large missile shall be a solid S4S nominal 2x4 #2 surface dry Southern Pine. The weight of the missile shall be as specified in Section 1626.2.3 of the *Florida Building Code, Building* and shall have a length of not less than 7 feet and not more than 9 feet. The missile shall be marked/ticked in dark ink at one inch intervals on center, and congruently numbered every three inches. A sabot shall be attached to the trailing edge of the missile to facilitate launching. The weight of the sabot shall not exceed $^1/_2$ lb. The combined weight of the timber and sabot, which constitutes the missile, shall be between 9 lb and 9.5 lb. The missile shall be propelled through a cannon as described in Section 6.3.3 of this protocol.

6.3.2.2 When testing any specimen with more than one component, in addition to complying with the impacts required by Section 1626.2 of the *Florida Building Code, Building* the framing member connecting these components shall be impacted at one half the span of such member with the large missile at a speed indicated in Section 1626.2.4 of the *Florida Building Code, Building*.

6.3.2.3 Any specimen that passes the large missile impact test need not be tested for the small missile impact test if the specimen has no opening that a $^3/_{16}$ inch sphere can pass through.

6.3.3 *LARGE MISSILE CANNON* - The large missile cannon shall use compressed air to propel the large missile. The cannon shall be capable of producing impact at the speed specified in Section 1626.2.4 of the *Florida Building Code, Building*. The missile cannon shall consist of four major components: a compressed air supply, a pressure release valve, a pressure gauge, a barrel and support frame, and a timing system for determining the missile speed. The barrel of the missile cannon shall consist of a 4-inch inside diameter pipe and shall be at least as long as the missile. The barrel of the large missile cannon shall be mounted on a support frame in a manner to facilitate aiming the missile so that it impacts the specimen at the desired location. The distance from the end of the cannon to the specimen shall be 9 feet plus the length of the missile.

6.3.4 *SMALL MISSILE* - The missiles shall be propelled through cannon as described in Section 6.3.5 of this protocol. The small missile shall be launched in such a manner that each specimen shall be impacted over an area not to exceed two square feet per impact as described in Section 1626.3.5 of the *Florida Building Code, Building*.

6.3.5 *SMALL MISSILE CANNON* - A compressed air cannon shall be used that is capable of propelling missiles of the size and speed defined in 1626.3.3 and 1626.3.4 of the *Florida Building Code, Building*. The cannon assembly shall be comprised of a compressed air supply and gauge, a remote firing device and valve, a barrel, and a timing system. The small missile cannon shall be mounted to prevent movement of the cannon so that it can propel missiles to impact the test specimen at points defined in 1626.3.5 of the *Florida Building Code, Building*. The timing system shall be positioned to measure missile speed within 5 feet of the impact point on the test specimen.

7. Hazards:

7.1 Testing facilities must take all necessary precautions to protect the observers during the entire test procedure. All observers shall always be at a safe distance away from specimen and apparatus. Safety regulations must be followed in order to avoid any injuries to any and all observers.

8. Testing Facilities (For a more detailed description see TAS 301-94.)

8.1 Any testing facility wishing to perform this test must first obtain the approval of the Authority Having Jurisdiction. Such approval shall only be given to those facilities which show that they are properly equipped to perform the complete test, including the cyclic loading and the small and large missile impact test. Testing facilities shall request, in writing, approval of their facilities. Such request shall contain the ability of the facility to perform all aspects of the test, all equipment used in the performance of the test, name of independent agency calibrating their equipment, location of facilities, personnel involved in the testing, a quality control program, a safety program and any other pertinent information which will clearly indicate that such facility is in the business of performing independent testing. The Authority Having Jurisdiction will visit the site and reserve the right to order any changes necessary to accept the facility for testing.

8.2 Approval of facilities to perform the test described in this protocol, does not constitute an approval of such facilities to perform other tests not specifically mentioned in this protocol.

9. Format of Test:

The manufacturer shall notify the Authority Having Jurisdiction seven (7) working days prior to the performing of the test. The Authority Having Jurisdiction reserves the right to observe the test. The Authority Having Jurisdiction must be notified of the place and time the test will take place. The test must be recorded on video and retained by the laboratory per TAS 301.

10. Test Reports:

The following minimum information shall be included in the submitted report:

10.1 Date of the test and the report, and report number.

10.2 Name, location, and certification number of facilities performing the test.

10.3 Name and address of requester of the test.

10.4 Identification of the specimen (manufacturer, source of supply, dimension, model types, material, procedure of selection and any other pertinent information).

10.5 Detailed drawings of the specimen showing dimensioned section profiles, type of framing specimen was attached to, panel arrangement, installation and spacing of anchorage, locking arrangement, sealants, hardware, product markings and their location, and any other pertinent construction details. Any deviation from the drawings or any modifications made to the specimen to obtain the reported values shall be noted on the drawings and in the report.

10.6 Maximum deflection recorded and mechanism used to make such determination.

10.7 Permanent deformation (provide cross section diagram to show where it occurred).

10.8 Name, address, signature and seal of Florida professional engineer, witnessing the test and preparing the report. Engineer shall be part of the laboratory's permanent staff or under laboratory's contract. (See TAS 301-94.)

10.9 The results for all three specimens shall be reported, each specimen being properly identified, particularly with respect to distinguishing features or differing adjustments. A separate drawing for each specimen will not be required if all differences between them are noted on the drawings provided.

10.10 Location of impacts on each test specimen.

10.11 The large and small missile velocities.

10.12 The weight of the missiles.

10.13 Maximum positive and negative pressures used in the cyclic wind pressure loading.

10.14 A description of the condition of the test specimens after testing, including details of any damage and any other pertinent observations.

10.15 When the tests are made to check conformity of the specimen to a particular specification, an identification or description of that specification.

10.16 A statement that the tests were conducted in accordance with this test method.

10.17 A statement of whether or not, upon completion of all testing, the specimens meet the requirements of Section 1626 of the *Florida Building Code, Building.*

10.18 A statement as to whether or not tape or film, or both were used to seal against air leakage, and whether in the judgment of the test engineer, the tape or film influenced the results of the test.

10.19 Signatures of persons responsible for supervision of the tests and a list of official observers.

10.20 All data not required herein, but useful to a better understanding of the test results, conclusions or recommendations, should be appended to the report.

11. Recording Deflections:

Maximum Deflection
Permanent Deformation

12. Additional Testing:

12.1 Following successful completion of this test, all specimen must then be successfully tested as per TAS 203-94.

12.2 Any product, when installed that is subjected to weathering, where such weathering can affect the integrity of the product, the manufacturer shall contact the Authority Having Jurisdiction for additional testing requirements such as but not limited to moisture, U.V., accelerated aging, and other similar tests.

12.3 The Authority Having Jurisdiction reserves the right to require any additional testing necessary to assure full compliance with the intent of the *Florida Building Code, Building.*

12.4 Some products, such as, but not limited to exterior doors, exterior windows, skylights, and wall cladding shall be required to be successfully tested under TAS 202-94 prior to conducting tests under this protocol.

13. Product Marking:

13.1 Any and all approved products shall be permanently labeled with the manufacturer's name, city, state, and the following statement: "Product Approved."

13.2 Permanently labeled shall be a metallic label fixed permanently to the frame of the specimen by rivets or permanent adhesive. See Section 13.2.1 of this protocol for storm panels.

13.2.1 Permanent label on storm panels could be printed directly on each panel at intervals not to exceed 24 inches with non removable paint or ink.

13.3 Any instructions for operations shall be permanently mounted on the specimen in an area not subject to be painted or concealed. Storm panels may be excluded from this section.

TESTING APPLICATION STANDARD (TAS) 202-94

CRITERIA FOR TESTING IMPACT & NONIMPACT RESISTANT BUILDING ENVELOPE COMPONENTS USING UNIFORM STATIC AIR PRESSURE

1. Scope:

1.1 This protocol covers procedures for conducting a uniform static air pressure test for materials and products such as wall cladding, glass block, exterior doors, garage doors, skylights, exterior windows, storm shutters, and any other external component which help maintain the integrity of the building envelope.

2. Referenced Documents:

2.1 *The Florida Building Code, Building*

2.2 ASTM Standards

3. Terminology:

3.1 *Definitions* - For definitions of terms used in this protocol, refer to the *Florida Building Code, Building.*

3.2 *Description of Terms Specific to This Protocol*

3.2.1 *Specimen* - The entire assembled unit submitted for test, including anchorage devices and structure to which product is to be mounted.

3.2.2 *Test Chamber* - An airtight enclosure of sufficient depth to allow unobstructed deflection of the specimen during pressure loading, including ports for air supply and removal, and equipped with a device to measure test pressure differentials.

3.2.3 *Maximum Deflection* - The maximum displacement measured to the nearest $^1/_8$ inch attained from an original position while a maximum load is being applied.

3.2.4 *Permanent Deformation* - The permanent displacement measured to the nearest $^1/_8$ inch from an original position that remains after maximum test load has been removed.

3.2.5 *Design Pressure (Design Wind Load)* - The uniform static air pressure difference, inward or outward, for which the specimen would be designed under service load conditions using the *Florida Building Code, Building* Section 1620.

3.2.6 *Test load* - One and one-half (1.5) times the design pressure (positive or negative) as determine by Section 1620 of the *Florida Building Code, Building* for which the specimen is to be tested, expressed in psf.

3.2.7 *Specimen Failure* - A change in condition of the specimen indicative of deterioration under repeated load or incipient failure, such as cracking, fastener loosening, local yielding, or loss of adhesive bond.

4. Significance and Use:

4.1 The test procedures outlined in this protocol provide a means of determining whether a particular product used as wall cladding, exterior windows, glazing, exterior doors, garage doors, skylights, glass block, storm shutters, and any other similar device used as external protection to maintain the envelope of the building, provides sufficient resistance to wind forces as determine by Section 1620 of the *Florida Building Code, Building.*

5. Test Specimen and Procedures:

5.1 *Test specimen* - All parts of the test specimen shall be full size, using the same materials, details, methods of construction and methods of attachment as proposed for actual use. The specimen shall consist of the entire assembled unit attached to a given type of structural framing of the building, and shall contain all devices used to resist wind forces.

In the case of windows, doors, and sliding glass doors, a pressure treated nominal 2 x 4 wood buck #3 Southern Pine shall be used for attachment of the specimen to the test frame/stand/chamber. Such wood buck will become part of the approval.

In the case of storm panels, they must be tested in worst case scenarios where attachments are directly to CBS block. Figure 1 shows the basic three (3) configurations that shall be required; one per each of the three (3) required specimens. Each storm panel specimen shall consist of minimum three (3) panels.

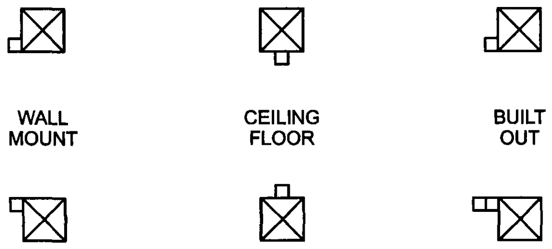


FIGURE 1
THREE (3) BASIC STORM PANEL ATTACHMENTS FOR TESTING

5.1.1 Locking mechanisms shall be permanently mounted on the specimen. Such locking mechanism shall require no tools to be latched in the locked position. Devices such as pins shall be permanently secured to the specimen through the use of chains or wires which must be of corrosion resistant material. This section does not apply to specimens referenced in Section 2413 of the *Florida Building Code, Building*.

5.1.2 Products that are not categorized as means of egress/escape and are provided with more than one single action locking mechanism, shall be provided with permanently posted instructions on latching for high wind pressures.

5.1.3 Doors and windows shall be operable after this test.

5.1.4 Specimen and fasteners, when used, shall not become disengaged during test procedure.

5.2 *Procedure*

5.2.1 Preparation - Remove from the test specimen any sealing or construction material that is not normally used when installed in or on a building. Fit the specimen with its structural framing into or against the chamber opening. The outdoor side of the specimen shall face the higher pressure side for positive loads; the indoor side shall face the higher pressure side for negative loads. Support and secure the specimen by the same number and type of anchors to be approved for normal installation of the specimen in the building.

5.2.2 *Single Action Locking/Closing Procedure*

5.2.2.1 All specimens which are required to comply with means of egress/escape, shall be tested for full static loads as required by Section 5.2.3 of this protocol with only one single action locking mechanism. Additionally, doors and windows that are not required to comply with means of egress/escape requirement shall be tested as described in Sections 5.2.2.2 and 5.2.2.3 of this protocol.

5.2.2.2 In the case of doors and windows that are not required to comply with the means of egress/escape requirements which are provided with more than one single action hardware and comply with the test described in this protocol, shall also be successfully tested with a test load equal to a static air pressure based on wind velocity of 75 mph using only one single action locking mechanism. Apply the corresponding positive test load and hold for 30 seconds. Release this test load across the specimen, and after a recovery period of not less than 1 minute nor more than 5 minutes, apply the corresponding reverse test load and hold for 30 seconds. Release the reverse test load and record observations. Such products must have all additional locking mechanisms permanently attached to the product by means of nonremovable and noncorrosive devices, and must comply with Section 5.1.1 of this protocol.

5.2.2.3 For product categories listed in 5.2.2.2 of this protocol, deliver and maintain water spray at a minimum rate of 5 gph/sf, applied at a pressure equal to not less than 15% of air pressure based on wind velocity of 75 mph. Maintain this pressure and water spray for a period not less than 15 minutes. No water infiltration shall occur. For this portion of the test, the only specimen that will be excluded is garage doors.

5.2.3 Uniform Static Air Procedure

5.2.3.1 Check specimen for adjustment and engage all locks.

5.2.3.2 Install all required measurement devices.

5.2.4 Apply one half (0.5) of the test load and hold for 30 seconds (for plastic glazed skylights apply the full test load). Release the test load across the specimen, and after a recovery period of not less than 1 minute nor more than 5 minutes, apply one half the reverse test load (for plastic glazed skylights apply the reverse full test load) and hold for 30 seconds. Release reverse test load and after a recovery period of not less than 1 minute nor more than 5 minutes record all readings.

5.2.5 Apply full test load and hold for 30 seconds, (for plastic glazed skylights apply two times the test load). Release the test load across the specimen, and after a recovery period of not less than 1 minute nor more than 5 minutes, apply full reverse test load (for plastic skylights apply two times the reverse test load) and hold for 30 seconds. Release reverse test load and after a recovery period of not less than 1 minute nor more than 5 minutes record all readings.

5.2.6 Deliver and maintain water spray at a minimum rate of 5 gph/sf, applied at a pressure equal to not less than 15% of design pressure, maintain this pressure and water spray for a period not less than 15 minutes. No water infiltration shall occur. For this portion of the test, the only systems that will be excluded are garage doors and storm shutters.

5.2.7 Air Infiltration - Shall comply with ASTM E 283-91.

5.3 Specimens successfully tested shall qualify assemblies with material thicker and of the same type and construction, provided the anchorage of the product is proportionally changed according to the wind pressure test.

5.4 Specimens successfully tested shall qualify assemblies of a smaller size and of the same type and construction, provided the anchorage of the product remains unchanged.

6. Apparatus:

6.1 The description of the apparatus is general in nature. Any equipment, properly certified, calibrated, and approved by the Authority Having Jurisdiction capable of performing this test within the allowable tolerance is permitted.

6.2.1 Test Chamber - The test chamber, to which the specimen is mounted, shall be provided with pressure taps to measure the pressure difference across the test specimen and shall be so located that the reading is unaffected by the velocity of air supplied to or from the chamber. The specimen mounting frame must not deflect under test load in such manner that the performance of the specimen will be affected.

6.2.2 Pressure-Measuring Apparatus - The pressure-measuring apparatus shall measure the test pressure difference within a tolerance of ±2%

6.2.3 Deflection-Measuring System - The deflection-measuring system shall measure the deflection within a tolerance of 0.01 of an inch.

6.2.4 Air System - A controllable blower, a compressed-air supply, an exhaust system, or reversible controllable blower designed to provide the required maximum air pressure difference across the specimen. The system shall provide an essentially constant air-pressure difference for the required test period.

6.2.5 Water-Spray System - The water-spray system shall deliver water uniformly against the exterior surface of the test specimen at a minimum rate of 5.0 gph/sf. The water-spray system shall have nozzles spaced at a uniform grid, located at uniform distance, and be adjustable to provide the specified quantity of water in such a manner as to wet the test specimen uniformly and to wet those areas vulnerable to water leakage.

6.3 Calibration of Equipment - The pressure-measuring apparatus and the deflection-measuring system shall be calibrated and certified by an independent qualified agency approved by the Authority Having Jurisdiction, at two year intervals.

6.3.1 The calibration report shall include: the date of the calibration, the name of the agency conducting the calibration, methods and equipment used in the calibration process, the equipment being calibrated and any pertinent comments.

7. Hazards:

7.1 Testing facilities must take all necessary precautions to protect the observers during the entire test procedure. All observers shall always be at a safe distance away from specimen and apparatus. Safety regulations must be followed in order to avoid any injuries to any and all observers.

8. Testing Facilities (For a more detailed description see TAS 301-94.):

8.1 Any testing facility wishing to perform this test must first obtain the approval of the Authority Having Jurisdiction. Such approval shall only be given to those facilities which show that they are properly equipped to perform the complete test. Testing facilities shall request, in writing, approval of their facilities. Such request shall contain the ability of the facility to perform all aspects of the test, all equipment used in the performance of the test, name of independent agency calibrating their equipment, location of facilities, personnel involved in the testing, a quality control program, a safety program and any other pertinent information which will clearly indicate that such facility is in the business of performing independent testing. The Authority Having Jurisdiction will visit the site and reserve the right to order any changes necessary to accept the facility for testing.

8.2 Approval of facilities to perform the test described in this protocol, does not constitute an approval of such facilities to perform other tests not specifically mentioned in this protocol.

9. Format of Test:

The manufacturer shall notify the Authority Having Jurisdiction seven (7) working days prior to the performing of the test. The Authority Having Jurisdiction reserves the right to observe the test. The Authority Having Jurisdiction must be notified of the place and time the test will take place. The test must be recorded on video and retained by the laboratory per TAS 301.

10. Test Reports:

The following minimum information shall be included in the submitted report:

10.1 Date of the test and the report, and report number.

10.2 Name and location of facilities performing the test.

10.3 Name and address of requester of the test.

10.4 Identification of the specimen (manufacturer, source of supply, dimension, model types, material, procedure of selection and any other pertinent information).

10.5 Detailed drawings of the specimen showing dimensioned section profiles, type of framing specimen was attached to, panel arrangement, installation and spacing of anchorage, locking arrangement, sealant, hardware, product markings and their location, and any other pertinent construction details. Any deviation from the drawings or any modifications made to the specimen to obtain the reported values shall be noted on the drawings and in the report.

10.6 Maximum deflection recorded and mechanism used to make such determination.

10.7 Permanent deformation (provide cross section diagram to show where it occurred).

10.8 Name, address, signature and seal of Florida Professional Engineer, witnessing the test and preparing the report. Engineer shall be part of the laboratory's permanent staff or under laboratory's contract. (See TAS 301-94.)

10.9 A tabulation of pressure differences exerted across the specimen during the test and their duration.

10.10 Maximum positive and negative pressures used in the test.

10.11 A description of the condition of the test specimens after testing, including details of any damage and any other pertinent observations.

10.12 When the tests are made to check conformity of the specimen to a particular specification, an identification or description of that specification.

10.13 A statement that the tests were conducted in accordance with this test method.

10.14 A statement of whether or not, upon completion of all testing, the specimens meet the requirements of Section 1620 of the *Florida Building Code, Building* and this protocol.

10.15 A statement as to whether or not tape or film, or both were used to seal against air leakage, and whether in the judgment of the test engineer, the tape or film influenced the results of the test.

10.15 Signatures of persons responsible for supervision of the tests and a list of official observers.

10.16 All data not required herein, but useful to a better understanding of the test results, conclusions or recommendations, should be appended to the report.

11. Recording Deflections:

Maximum Deflection
Permanent Deformation

12. Additional Testing:

12.1 After successfully completing all parts of the test described in this protocol, the specimen shall be subjected to the forced entry test per ASTM F 588, ASTM 842, or AAMA 1304 as applicable.

12.2 Any product when installed that is subjected to weathering, where such weathering can affect the integrity of the product, the manufacturer shall contact the Authority Having Jurisdiction for additional testing requirements such as but not limited to moisture, U.V., accelerated aging, and other similar tests.

12.3 The Authority Having Jurisdiction reserves the right to require any additional testing necessary to assure full compliance with the intent of the *Florida Building Code, Building*.

13. Product Marking:

13.1 Any and all approved products shall be permanently labeled with the manufacturer's name, city, state, and the following statement: "Product Approved."

13.2 Permanently labeled shall be a metallic label fixed permanently to the frame of the specimen by rivets or permanent adhesive. See Section 13.2.1 of this protocol for storm panels.

13.2.1 Permanent label on storm panels could be printed directly on each panel at intervals not to exceed 24 inches with nonremovable paint or ink.

13.3 Any instructions for operations shall be permanently mounted on the specimen in an area not subject to be painted or concealed. Storm panels may be excluded from this section.

TESTING APPLICATION STANDARD (TAS) 203-94

CRITERIA FOR TESTING PRODUCTS SUBJECT TO CYCLIC WIND PRESSURE LOADING

1. Scope:

1.1 This protocol covers procedures for conducting the cyclic wind pressure loading test required by the *Florida Building Code, Building* and TAS 201-94.

2. Referenced Documents:

2.1 *The Florida Building Code, Building*

3. Terminology:

3.1 Definitions - For definitions of terms used in this protocol, refer to the *Florida Building Code, Building.*

3.2 Description of Terms Specific to This Protocol.

3.3 Specimen - The entire assembled, unit submitted for test, including anchorage devices and structure to which product is to be mounted.

3.4 Positive (Negative) Cyclic Load - the specified differential in static air pressure, creating an inward (outward) loading, for which the specimen is to be tested under repeated conditions, expressed in pounds per square foot.

3.5 One Cycle - Beginning at the specified static air pressure, the application of positive cyclic test load, and returning to the specified static air pressure, followed by the application of negative cyclic test load.

3.6 Design Wind Load - The uniform static air pressure difference, inward or outward, for which the specimen would be designed under service load conditions using the *Florida Building Code, Building* Section 1606.

3.7 Test Chamber - An airtight enclosure of sufficient depth to allow unobstructed deflection of the specimen during pressure cycling, including ports for air supply and removal, and equipped with a device to measure test pressure differentials.

3.8 Maximum Deflection - The maximum displacement measured to the nearest $^1/_8$ inch attained from an original position while the maximum load is being applied.

3.9 Permanent Deformation - The permanent displacement measured to the nearest $^1/_8$ inch from an original position that remains after the applied test load has been removed.

3.10 Specimen Failure - A change in condition of the specimen indicative of deterioration under repeated load or incipient failure, such as cracking, fastener loosening, local yielding, or loss of adhesive bond.

4. Significance and Use:

4.1 This test method is a standard procedure for determining compliance with Sections 1625, Table 1625.4 and Table 1626 of the *Florida Building Code, Building*. This test method is intended to be used for installations of exterior windows, glazing, wall cladding, exterior doors, skylights, glass block, storm shutters, and other similar device used as external protection of the building envelope. This test method consists of supplying air to and exhausting air from the chamber in accordance with a specific test loading program at the rate required to maintain the test pressure differential across the specimen, and observing, measuring, and recording the deflection, deformations, and nature of any distress or failures of the specimen.

5. Test Specimen:

5.1 Test specimen - All parts of the test specimen shall be full size, using the same materials, details, methods of construction and methods of attachment as proposed for actual use. The specimen shall consist of the entire assembled unit attached to a given type of structural framing of the building, and shall contain all devices used to resist wind forces and windborne debris. When testing glazed products, the material used to make such glazed product windborne debris resistant (i.e. fillers, film and similar), shall be an integral part, factory applied, of such glazed product.

In the case of windows, doors, and sliding glass doors, a pressure treated nominal 2 x 4 wood buck #3 Southern Pine shall be used for attachment of the specimen to the test frame/stand/chamber. Such wood buck will become part of the approval.

In the case of storm panels, they must be tested in worst case scenarios where attachments are directly to CBS block. Figure 1 shows the basic three (3) configurations that shall be required; one per each of the three (3) required specimens. Each storm panel specimen shall consist of minimum three (3) panels.

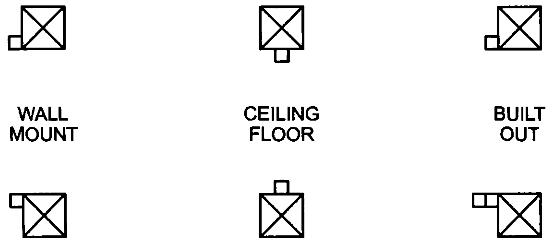


FIGURE 1
THREE (3) BASIC STORM PANEL ATTACHMENTS FOR TESTING.

5.1.1 Locking mechanisms shall be permanently mounted on the specimen. Such locking mechanism shall require no tools to be latched in the locked position. Devices such as pins shall be permanently secured to the specimen through the use of chains or wires which must be of corrosion resistant material. This section does not apply to specimens referenced in Section 2422 of the *Florida Building Code, Building*.

5.1.2 Products that are not categorized as means of egress/escape and are provided with more than one single action locking mechanism, shall be provided with permanently posted instructions on latching for high wind pressures.

5.1.3 Specimen and fasteners, when used, shall not become disengaged during test procedure.

5.2 If the impact test is to be performed on the test specimen, such test shall be conducted prior to performing the test described in this protocol.

5.3 All locking mechanisms should be in place when performing this test.

5.4 Doors and windows must be operable after this test.

6. Procedure:

6.1 Preparation - Remove from the test specimen any sealing or construction material that is not normally used when installed in or on a building. Fit the specimen with its structural framing into or against the chamber opening. The outdoor side of the specimen shall face the higher pressure side for positive loads; the indoor side shall face the higher pressure side for negative loads. Support and secure the specimen by the same number and type of anchors to be approved for normal installation of the specimen in the building.

6.2 Support and secure the test specimen by the same number and type of anchors normally used in installing the unit in the building.

6.3 Load the specimen using the cycles specified in section Table 1625.4 and/or Table 1626 of the *Florida Building Code, Building* whichever of these apply.

6.4 In the case of Table 1625.4 of the *Florida Building Code, Building* Section 6.3 of this protocol must be repeated for negative pressures.

6.5 Assemblies shall be tested with no resultant failure or distress and shall have a recovery of at least 90% over maximum deflection. Test Temperature. The test shall be conducted at a test temperature range of 59 to 95 degrees F (15 to 35 degrees C).

7. Apparatus:

7.1 The description of the apparatus is general in nature. Any equipment, properly certified, calibrated, and approved by Authority Having Jurisdiction capable of performing this test within the allowable tolerance is permitted.

7.2 Major Components

7.2.1 Test Chamber - The test chamber, to which the specimen is mounted, shall be provided with pressure tabs to measure the pressure difference across the test specimen and shall be so located that the reading is unaffected by the velocity of air supplied to or from the chamber. The specimen mounting frame must not deflect under test load in such manner that the performance of the specimen will be affected.

7.2.2 Pressure-Measuring Apparatus - The pressure-measuring apparatus shall measure the test pressure difference within a tolerance of ±2%

7.2.3 Deflection-Measuring System - The deflection-measuring system shall measure the deflection within a tolerance of 0.01 inch.

7.2.4 Air System - A controllable blower, a compressed-air supply, an exhaust system, or reversible controllable blower designed to provide the required maximum air pressure difference across the specimen. The system shall provide an essentially cyclic static air-pressure difference for the required test period.

7.3 Calibration of Equipment - The pressure-measuring apparatus and the deflection-measuring system shall be calibrated and certified by an independent qualified agency approved by the Authority Having Jurisdiction, at two-year intervals.

7.3.1 The calibration report shall include: the date of the calibration, the name of the agency conducting the calibration, methods and equipment used in the calibration process, the equipment being calibrated and any pertinent comments.

8. Hazards:

8.1 Testing facilities must take all necessary precautions to protect the observers during the entire test procedure. All observers shall always be at a safe distance away from specimen and apparatus. Safety regulations must be followed in order to avoid any injuries to any and all observers.

9. Testing Facilities (For a more detailed description see TAS 301-94):

9.1 Any testing facility wishing to perform this test must first obtain the approval of the Authority Having Jurisdiction. Such approval shall only be given to those facilities which show that they are properly equipped to perform the complete test. Testing facilities shall request, in writing, approval of their facilities. Such request shall contain the ability of the facility to perform all aspects of the test, all equipment used in the performance of the test, name of independent agency calibrating their equipment, location of facilities, personnel involved in the testing, a quality control program, a safety program and any other pertinent information which will clearly indicate that such facility is in the business of performing independent testing. The Authority Having Jurisdiction will visit the site and reserve the right to order any changes necessary to accept the facility for testing.

9.2 Approval of facilities to perform the test described in this protocol, does not constitute an approval of such facilities to perform other tests not specifically mentioned in this protocol.

10. Format of Test:

The manufacturer shall notify the Authority Having Jurisdiction seven (7) working days prior to the performing of the test. The Authority Having Jurisdiction reserves the right to observe the test. The Authority Having Jurisdiction must be notified of the place and time the test will take place. The test must be recorded on video and retained by the laboratory per TAS 301.

11. Test Reports:

The following minimum information shall be included in the submitted report:

11.1 Date of the test and the report, and report number.

11.2 Name and location of facilities performing the test.

11.3 Name and address of requester of the test.

11.4 Identification of the specimen (manufacturer, source of supply, dimension, model types, material, procedure of selection and any other pertinent information).

11.5 Detailed drawings of the specimen showing dimensioned section profiles, type of framing specimen was attached to, panel arrangement, installation and spacing of anchorage, locking arrangement, sealant, hardware, product markings and their location, and any other pertinent construction details. Any deviation from the drawings or any modifications made to the specimen to obtain the reported values shall be noted on the drawings and in the report.

11.6 Maximum deflection recorded and mechanism used to make such determination.

11.7 Permanent deformation (provide cross section diagram to show where it occurred).

11.8 Name, address, signature and seal of Florida professional engineer, witnessing the test and preparing the report. Engineer shall be part of the laboratory's permanent staff or under laboratory's contract. (See TAS 301-94.)

11.9 A tabulation of pressure differences exerted across the specimen during the test and their duration.

11.10 Maximum positive and negative pressures used in the test.

11.11 A description of the condition of the test specimens after testing, including details of any damage and any other pertinent observations.

11.12 When the tests are made to check conformity of the specimen to a particular specification, an identification or description of that specification.

11.13 A statement that the tests were conducted in accordance with this test method.

11.14 A statement of whether or not, upon completion of all testing, the specimens meet the requirements of Section 1606 of the *Florida Building Code, Building* and this protocol.

11.15 A statement as to whether or not tape or film, or both were used to seal against air leakage, and whether in the judgment of the test engineer, the tape or film influenced the results of the test.

11.16 Signatures of persons responsible for supervision of the tests and a list of official observers.

11.17 All data not required herein, but useful to a better understanding of the test results, conclusions or recommendations, should be appended to the report.

12. Recording Deflections:

Maximum Deflection
Permanent Deformation

13. Additional Testing:

13.1 Prior to conducting the test described in this protocol, all specimen must have successfully completed the test specified in protocol TAS 201-94.

13.2 Any product when installed that is subjected to weathering, where such weathering can affect the integrity of the product, the manufacturer shall contact the Authority Having Jurisdiction for additional testing requirements such as but not limited to moisture, U.V., accelerated aging, and other similar tests.

13.3 The Authority Having Jurisdiction reserves the right to require any additional testing necessary to assure full compliance with the intent of the *Florida Building Code, Building*.

13.4 Some products, such as exterior doors, exterior windows, skylights, and wall cladding shall be required to be successfully tested under TAS 202-94 prior to conducting tests under this protocol.

14. Product Marking:

14.1 Any and all approved products shall be permanently labeled with the manufacturer's name, city, state, and the following statement: "Product Approved."

14.2 Permanently labeled shall be a metallic label fixed permanently to the frame of the specimen by rivets or permanent adhesive. See Section 14.2.1 of this protocol for storm panels.

14.2.1 Permanent label on storm panels could be printed directly on each panel at intervals not to exceed 24 inches with nonremovable paint or ink.

14.3 Any instructions for operations shall be permanently mounted on the specimen in an area not subject to be painted or concealed. Storm panels may be excluded from this section.

TESTING APPLICATION STANDARD (TAS) 301-94

TESTING LABORATORY

1. Scope:

1.1 This protocol describes the requirements for certification and registration of a testing laboratory to perform a given test for approving products, materials and/or methods of construction, to be used in the High-Velocity Hurricane Zone.

2. Eligibility:

2.1 Any testing agency or organization meeting the requirements set forth in this protocol and considering itself to provide independent evaluation of products, materials and/or methods of construction, may apply with The Authority Having Jurisdiction for certification and registration of its facilities.

3. Testing Facility:

3.1 Each test facility shall have sufficient personnel, having the necessary education, training, technical knowledge and experience for their assigned functions.

3.2 The laboratory shall ensure that the training of its personnel is kept up-to-date.

3.3 Records of relevant qualifications, training, skills and experience of the technical personnel shall be maintained by the laboratory.

3.4 A Florida-registered professional engineer proficient in the discipline required for the test, shall be part of the laboratory's permanent staff or under laboratory's contract to witness and certifying the test performed. (This professional engineer shall not be involved in any manner in the design of the specimen being tested and/or the test requester or manufacturer).

3.5 Testing facility shall be of sufficient size to be able to properly accommodate all necessary equipment required to correctly conduct a given test described in protocols prepared by the Authority Having Jurisdiction and/or the *Florida Building Code, Building* and yet provide adequate clearance.

3.6 Testing facility shall have an established Emergency Action Plan. Such plan be included in every workplace, or parts thereof, and shall describe what procedures the employer, employees and visitors must take to ensure their safety from fire and other emergencies. Such plan shall include but not be limited to fire extinguishing devices and first aid kits.

3.7 Testing facility shall be equipped with stationary (adjustable) video recorder to record the test being performed. Additional video recorders are encouraged to be used to capture different angle perceptions.

3.8 Testing facility shall have adequate ventilation as required by the test apparatus and the *Florida Building Code, Building*.

3.9 The Authority Having Jurisdiction will visit the testing facilities unannounced, and reserve the right to order necessary changes to the facilities for approval of such facility.

3.10 Testing facility shall adequately keep all records of test performed. Such records shall be readily available to the Authority Having Jurisdiction for inspection. Such reports must be kept for a period of not less than ten (10) years.

3.11 Testing facility shall adequately keep all records of calibration of equipment. Such records shall be readily available to the Authority Having Jurisdiction for inspection.

3.12 Testing facility shall adequately keep a quality control program and safety program. Such programs shall be readily available to the Authority Having Jurisdiction for inspection.

3.13 If the testing facility is involved in remote testing, in addition to complying with all the requirements listed in this protocol, such facility must demonstrate that it is properly equipped to transport all necessary equipment to the test site. Such equipment must be properly stowed at the facility location at the end of each day.

4. Occupational Exposure:

4.1 Noise - Protection against the effects of noise exposure shall be provided when the sound levels exceed 140 dB peak sound pressure levels from exposure to impulsive or impact noise, or 100 dB from exposure to continuous noise.

4.2 Eye and Face Protection - Protective eye and face equipment shall be required where there is a reasonable probability of injury that can be prevented by such equipment. This equipment shall provide adequate protection against the particular hazards for which they are designed.

5. Calibrations:

5.1 The laboratory shall schedule for calibration audits of its equipment at intervals not to exceed those required by individual test procedures or protocols to verify that its operations continue to comply with the requirements of the quality system. Where the audit findings cast doubt on the correctness or validity of the laboratory's calibrations or test results, the laboratory shall take immediate corrective action and shall immediately notify, in writing, the Authority Having Jurisdiction and any client whose work may have been affected.

5.2 All calibration findings and any corrective actions that arise from them shall be documented and filed with the Authority Having Jurisdiction. The person responsible for quality control program of the laboratory shall ensure that these actions are properly executed.

6. Submittals:

6.1 Name, address, contact person and telephone number of testing facility.

6.2 Name and registration number of Florida-Registered Professional Engineer as stated in Section 3.4 of this protocol.

6.3 Resume of qualification of personnel involved in testing.

6.4 List of all equipment, located at the facility, by name, model and serial number.

6.5 Name, address, contact person and telephone number of independent agency performing calibration of equipment.

6.6 List of test(s) to be performed.

6.7 Copy of facility's quality control program.

6.8 Copy of facility's safety program.

6.9 Copy of facility's table of organization.

6.10 Copy of facility's occupational license.

6.11 Statement indicating the period of time that facility has been involved in the independent testing business.

6.12 Letter requesting certification and registration of facility.

6.13 Independence statement.

7. Independence:

7.1 The statement of independence shall be submitted on testing laboratory's stationary and signed by an official of the testing laboratory. The statement shall include the following:

7.1.1 A statement indicating that the laboratory or agency, its associates, entities or legal persons employed or under contract do not have any financial interest in any product manufacturing company other than providing professional testing services.

7.1.2 A statement indicating that the laboratory or agency is not owned, operated or controlled by any company manufacturing or distributing any portion of the product inspected or tested.

8. Termination of Certification and Registration of Testing Facility:

8.1 At any time the facility may voluntarily terminate its certification and registration with the Authority Having Jurisdiction, either in its entirety or with respect to any particular test, simply by giving written notification to the Building Code Compliance Office. Such written notification shall state the date as of which the termination is to take place. The Building Code Compliance Office shall remove the name of the facility from the approved list.

8.2 If at any time the facility has failed to continue to substantially satisfy the requirements of this protocol, or has not been reasonably performing the testing requirements encompassed within the letter of certification and registration issued by The Authority Having Jurisdiction, or has materially misrepresented itself in its letter of request for certification and registration, or has misrepresented the scope or conditions of its approval, or has misrepresented the results or conditions under which a given test was performed, the Authority Having Jurisdiction may revoke the approval of such facility immediately by written notice to the contact person of the testing facility.

9. Significance of Protocol:

9.1 This protocol provides means of determining whether a particular independent testing laboratory meets the specified criteria as set by the *Florida Building Code, Building* and/or requirements as set by the Authority Having Jurisdiction.

10. Duration of Approval:

10.1 In case of any changes to the test procedures or protocols, the Authority Having Jurisdiction reserves the right to request additional information or to revoke approval of a non-compliance facility.

11. Exceptions:

11.1 Testing performed by Underwriters Laboratories (UL), Factory Mutual (FM), and Canadian Standard Association (CSA) are exempt from these requirements.

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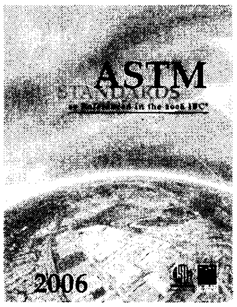
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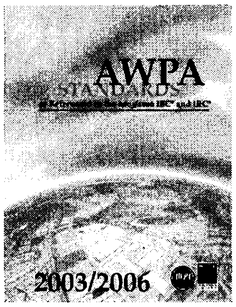
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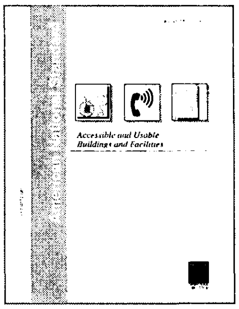
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